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AN INVESTIGATION TO DETERMINE THE UTILIZATION OF KNOWLEDGE BY ELECTRONIC TECHNICIANS IN ALBERTA INDUSTRY

A THESIS

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The undersigned hereby certify that they have read and recommended to the Faculty of Graduate Studies, a thesis entitled "An Investigation to Determine the Utilization of Knowledge by Electronic Technicians in Alberta Industry," submitted by Clare Anthony Sammons in partial fulfillment of the requirements for the degree of Master of Education.

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ABSTRACT

This study was conducted to determine whether there was a significant difference in the way electronic technicians who were classified as high job level or low job level utilized electronic knowledge. The study also investigated whether electronic instructors at the Northern Alberta Institute of Technology and electronic technicians classified by job level, perceived differently the utilization of electronic knowledge. Income was used as a measure of job level.

Sixty electronic technicians and eleven electronic instructors responded to a seventy-one item Q-sort instrument designed by Crocker (1969). This instrument was used to obtain a set of utilization scores along a five point generality scale for each subject. Utilization scores were subjected to one-way analysis of variance and the F test was used as a test for significance.

No significant differences were obtained between the high job level and low job level technician groups on the basis of mean utilization of knowledge items with the exception of the most general knowledge items. Low job level technicians perceived a higher mean utilization than high job level technicians for knowledge items classified as most general. Significant differences were obtained between the instructor group and each of the technician groups. Instructors perceived a higher mean utilization for most general knowledge items while technicians perceived a higher mean utilization for least general knowledge items.

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CHAPTER I

THE PROBLEM

I. INTRODUCTION

Knowledge of the educational requirements of workers has been regarded as one of the root factors underlying the development of technical curricula. Ginzberg (1969, p. 8) stated that

> More feedback is needed between educational and training institutions and the uses of manpower. Universities are remiss in collecting information about what happens to their graduates. And they seldom receive any feedback from the employers. Education and training institutions should undertake more follow-up studies and be in continuing contact with the employers of their graduates.

Roney (1965, p. 1) expressed the view that there is an urgent need for a more precise analysis of the relationship between the function of the technician and the education that can most effectively meet these requirements. The basic research tools for program planning have included the use of occupational surveys, advisory committees and occupational analyses (Brandon and Evans, 1965, p. 264). According to Whitworth (1969, p. 13) the use of such tools has been directed towards discovering the aptitudes, abilities, skills and such needed to perform the various jobs successfully with a view to discovering skills and knowledge for inclusion in the curriculum.

The identification of skills and information necessary for successful performance in specific trades or occupations has, according to Whitworth (1969, p. 10), relied upon trade and job analysis techniques. Gagne (1962, pp. 82-91), however, argued that

> The rise of occupations which require a high level of knowledge and a low level of manipulative skill demands new forms

of occupational analysis based on factors other than "operations" or "jobs".

Parnes (1962, p. 48) recognized that even specific occupations such as that of "electronic technician" represent abstractions from a large number of individual jobs whose functional content may be quite diverse.

Various classification schemes, therefore, have been proposed for the purpose of studying the knowledge and skill requirements of technicians. Differences in knowledge requirements as a function of job classification variables, such as type of equipment handled or type of job function, have been demonstrated by Barlow and Schill, (1962); Schill and Arnold, (1965); and Crocker, (1969; and such differences have been shown to have implications for programs of technical education.

Scoville, (1969), Fine, (1964) and Whitworth, (1969) have suggested that educational requirements may also be examined in terms of the "level" at which the technician functions. Higher job levels, in turn, would correspond with more complex job functions, higher skill levels and more responsibility. Scoville (1969, p. 29); and Gutcher, (1968, p. 4) proposed income as a measure of job level. Schill and Arnold, (1965, p. 65) examined the educational requirements of technicians in Illinois Industry in terms of job level by employing the income of the technician as a measure of job level. These authors noted a high positive correlation between job level and income received by the technician.

II. STATEMENT OF THE PROBLEM

It was the purpose of the present study to examine the knowledge items required by electronic technicians employed by Alberta Industry, in terms of job level occupied by the technician. A list of Alberta firms that employed electronic technicians was compiled by the Alberta Bureau of

Statistics for the study. A question of particular interest was the extent to which technicians at higher job levels required knowledge items which had a greater degree of generality than did technicians occupying lower job levels. The hypothesis that such differences might exist was predicted upon the assumption that technicians who occupied higher job levels would be expected to display more general educational needs than would technicians who occupied lower job levels. A second question investigated examined the extent to which instructors at the Northern Alberta Institute of Technology and electronic technicians from Alberta Industry differed in terms of their perception of the knowledge requirements expressed by the technicians.

A third question was concerned with the relating of a difference, if any, between the groups used in the testing of Hypothesis I below to such variables as age, amount of formal education, number of years of related work experience, and source of technical training.

III. STATEMENT OF HYPOTHESES

The following hypotheses were tested in this study:

(1) There will be no significant difference between high job level electronic technicians and low job level electronic technicians from Alberta Industry in mean utilization assigned to knowledge items within each category of a five point generality scale.

(2) There will be no significant difference between high job level electronic technicians and electronic instructors at the Northern Alberta Institute of Technology in mean utilization assigned to knowledge items within each category of a five point generality scale.

(3) There will be no significant difference between low job level

electronic technicians and electronic instructors from the Northern Alberta Institute of Technology in mean utilization assigned to knowledge items within each category of a five point generality scale.

(4) If a difference is found to exist between the groups used in the testing of Hypothesis I, is this difference related to such variables as:

(a) age
(b) amount of formal education
(c) number of years of related work experience, and
(d) source of technical training

IV. IMPORTANCE OF THE STUDY

The need to keep technical curricula up to date has been indicated by a number of writers. The American Association for the Advancement of Science-- Commission on Science Education announced that

> Technical educators and the employers of technicians should be fully aware of the rapidity of change in technical occupations and their corresponding educational requirements. Technical education curricula should be under continuous cooperative study by institutions and employers, and, to the extent possible, the need for change should be anticipated rather than accomodated. (American Association for the Advancement of Science, -- Commission on Science Education, 1968, p. 18)

Procedures for coping with such change have included the use of advisory committee systems, analyses based upon job specifications prepared by various companies that employ technicians, job-analysis schemes, expert opinion, follow-up surveys and the judgement exercised by educators responsible for the development of programs in technical education. Thus, it may be seen that the need for well developed procedures for securing information related to the knowledge and skills required by technicians has been indicated. (Crocker, 1969, pp. 29-37).

The diversity of individual jobs within the broad spectrum of electronics technology has resulted in the need to examine the knowledge requirements of technicians in terms of some suitable classification system. Studies by Barlow and Schill, (1962, pp. 29-31) and Crocker,

(1969, p. 89) have classified technicians on the basis of the tasks, duties or functions performed by the technicians. Such studies have tended to confirm the need for the inclusion of specialized subject matter within the technical curriculum. The need to examine the relationship between job level and knowledge requirements has, on the other hand, not received the same attention. Crocker, (1969, p. 223) indicated that the knowledge requirements of electronic technicians would need to be examined in terms of the job level held by the technician. It was hypothesized, for example, that research and development technicians may operate at more advanced levels than others. The question of the educational requirements of technicians as a function of job level, however, was not examined by Crocker.

The need to identify relevant knowledge requirements of technicians, has led to the use of instruments which employ rating scales. (Trego, 1958; Vasek, 1967; Weede, 1967, p. 9). Such studies have been motivated by the need to replace non-essential items in the technical curriculum with items which have greater relevance for the technician. Coupled with the need to identify relevant knowledge items, has been the need to determine the extent to which general rather than specific knowledge items may be required by the technician. Schill and Arnold (1965, p. 68) for example, proposed a continuum to represent the degree of generality of knowledge items employed to examine the requirements of technicians in Illinois Industry. They found that,

> ...it was necessary to design a continuum which would differentiate between subjects of a general nature and those dealing with the more specific aspects of a subject. Devising the general to specific continuum was based on the assumption that some courses are broader, or have wider, more general use or application than others.

It was hypothesized, then, that technicians who operate at more ad-

vanced levels may be expected to require knowledge items that have been rated as general rather than specific. Evidence of the knowledge requirements of technicians at more advanced job levels as compared to those at less advanced levels was required to clarify differences which may be expected to exist.

Many concerns have been expressed with regard to the degree of specialization as it affects the mobility of workers and requirements for retraining. Knowledge of the extent to which electronics technicians require specialized rather than generalized knowledge, then, may be expected to have implications for technical curriculum development. Crocker and others have utilized Q-technique to obtain data related to the needs of workers engaged in technical occupations. The present study attempted to relate the knowledge requirements of electronic technicians, as determined by a Q-sort instrument, to the job-level they occupied.

At the time of the study electronic programs were offered by three post-secondary and more than fifteen secondary institutions in Alberta. The number of students graduating from these programs per annum was greater than two hundred. Formal contact between firms that employ electronic technicians and technician educators in Alberta has for the most part been limited to Advisory Committees. Questions of the kind raised in this study, however, may be dealt with in only limited fashion by the Advisory Committee method. Thus, in order to provide educators of technicians with information of use to them in dealing with questions relating to the type of knowledge required by electronic technicians, systematic examination of knowledge requirements of electronic technicians in Alberta must be made. The present study was designed to provide such information in terms of electronic technicians employed by Alberta industry who

occupy high job levels versus those who occupy low job levels. The estimated total number of electronic technicians employed by Alberta industry was eight hundred. (Crocker, 1969).

V. DELIMITATIONS

The present study was confined to technicians whose major job specialization was electronics. Only technicians employed by Alberta firms were considered. No technicians were excluded from the study on the basis of length or kind of formal training.

The instructor group was comprised of instructors employed by the Northern Alberta Institute of Technology. Since no formally recognized academic prerequisite was defined for employment at the Northern Alberta Institute of Technology, the educational background and job experience of the instructor sample was varied. Included in the sample were five instructors with technical institute diplomas, five with four year university standing and two that had received technical training in the armed forces.

VI. LIMITATIONS OF THE STUDY

Limitations of the study may be classed as (1) limitations due to the sample selected, (2) limitations related to the instrument employed, and (3) other limitations.

Sample Limitations. Observations arising out of the study may be limited to areas where the composition of the technician population resembles that of the present study. Alberta has been identified primarily as a user area rather than as a manufacturing area of electronic products (Crocker, 1969, p. 13). The results, then, may be expected to have ap-

plication primarily to similar user areas where service and maintenance rather than production oriented functions are the rule.

Instrument limitations. A large number of personal factors have been considered to contribute to successful job performance. Several factors which have been identified form the basis for the worker trait requirement profile contained within the Dictionary of Occupational Titles. Among these factors are included such variables as interest, temperament, general educational development, specific vocational preparation, aptitudes, and physical factors. General factors such as interests, aptitudes, temperaments, and physical capacity were not included in the present study.

Subject matter from other disciplines such as mathematics, physics, and chemistry was not included in the data collection instrument, although the importance of such knowledge to the technician is not underrated by the writer. Independent studies have been conducted to determine the requirements of technicians for subject matter from other disciplines.

Other limitations. The present study has not attempted to assess the skill, aptitude or attitude requirements of electronic technicians, although these requirements may have a pronounced effect upon successful job performance. As well, no attempt was made to determine whether the worker performed successfully on the job.

The specific job functions, duties or tasks assigned to individual workers or in common between workers was not examined by the present study. The question of whether the worker was placed in a job where the tasks, duties and responsibilities were beneath or beyond his capability to perform successfully was also not examined directly. Blaug (1967) has examined the latter question in some detail.

VII. DEFINITION OF TERMS

For the purpose of this study the following definitions were employed.

Electronic technician. An electronic technician was defined as a person engaged in the design or development, operation or control, installation, maintenance, or sales of electronic equipment, subject to the following exclusions:

1. Excluded were persons holding a university degree in Science or Engineering.
2. Excluded were persons whose primary function was routine operation or sales, requiring no knowledge of the internal working of the equipment.
3. Excluded were persons engaged solely in the servicing of domestic appliances including radio and television receivers.

Job level. Job level was defined as the level at which the electronic technician performed the tasks, duties and responsibilities assigned him. Higher job levels were taken to indicate more complex job functions while lower job levels were taken to indicate less complex job functions.

High job level. High job level was defined as the level at which the electronic technician performed the tasks, duties and responsibilities assigned him; with higher job levels taken to indicate more complex job functions, more complex tasks and greater responsibility. High job level was operationally defined as the salary interval which included all the reported salaries received by electronic technicians in Alberta above weighted average value computed in the Alberta Technicians Salary Survey.

Low job level. Low job level was defined as the level at which the electronic technician performed the tasks, duties and responsibilities assigned him; with lower job levels taken to indicate less complex job functions, less complex tasks and less responsibility. Low job level was operationally defined as the salary interval which included all the reported salaries received by electronic technicians in Alberta below the weighted average value computed in the Alberta Technicians Salary Survey.

Alberta industry. Alberta industry was defined as those firms reported to have employed electronic technicians by the Alberta Bureau of Statistics. The list of firms that employed electronic technicians was derived from a broader summary of Alberta firms developed by the Alberta Bureau of Statistics for the purpose of describing the salaries received by technicians in Alberta.

Knowledge requirements. Knowledge requirements were defined as the electronic technicians response to the instrument employed in the study. The instrument originally developed by Crocker (1969) was designed to assess the knowledge requirements of Alberta electronic technicians and consisted of seventy-one knowledge items selected from the field of electronics.

VIII. PROCEDURE

The sample selected consisted of sixty electronic technicians employed by Alberta Industry at the time of the study. A list of Alberta firms that participated in the study is included in Appendix E. The list of firms, included in the study was derived from a listing of all firms in Alberta that were known to employ technicians at the time of the study and was prepared with the assistance of the Edmonton office of the Alberta Bureau of Statistics. The electronic technician salary range was obtained by

consulting the Alberta Technicians Salary Survey prepared by the Alberta Bureau of Statistics.

Letters to the individual firms were sent and arrangements were made to hold interviews with technicians selected at random from those employed by the firm. The technicians used in the sample were selected from each firm according to the schedule outlined in Table I.

The Q-sort instrument employed in the study was previously developed by Crocker (1969). It was originally employed to determine the knowledge requirements of electronic technicians in Alberta Industry in terms of certain job classification variables such as job function or type of equipment handled. The instrument consisted of seventy-one knowledge items representative of the field of electronics which were selected by the author from several electronics curricula. The instrument was employed in the present study in an unmodified form, to examine essentially the same population, however, the major categorical variable employed was that of job level.

The instrument was administered in an interview situation, at which time, additional personal data such as: age, number of years of formal education, and number of years of related job experience were also recorded.

Analysis of variance was employed to determine whether significant difference in mean ratings existed for items classified as to level of generality, between the groups of electronic technicians classified according to job level by the salary level they occupied. Analysis of variance was also employed to determine whether significant differences in mean ratings existed for items classified according to level of generality between the instructor group at the Northern Alberta Institute of Technology and each of the technician groups classified according to job level.

TABLE I

GUIDELINES FOR SELECTING TECHNICIAN SAMPLE

FROM ALBERTA ELECTRONIC FIRMS

Total Technicians Employed by Alberta Firms	Number Selected for Inclusion in Study
5 or less	1
6-10	3
11-25	5
26-50	8
51-100	12
more than 100	15

CHAPTER II

REVIEW OF RELATED LITERATURE

The major purpose of this chapter is to summarize the literature and research relating to the knowledge requirements of electronic technicians. In particular, the review attempted to focus upon the research on occupational classification for the purpose of investigating alternate means for examining the knowledge requirements of electronic technicians. Since the instrument employed in this investigation employed a Q-Sort procedure, the literature was also reviewed for the purpose of identifying procedures and limitations inherent in Q-sort.

The chapter has been divided into three main parts. Part one deals with the research on occupational classification. Part two deals with schemes for classifying electronic technicians and, finally, part three deals with the research related to the use of Q-Sort.

II. OVERVIEW

The literature reviewed for inclusion in this portion of the study focussed upon the relationship between studies conducted to determine knowledge requirements of persons employed as electronic technicians, and studies which have concentrated upon occupational classification. The purpose of such an examination was to reveal the extent to which existing views of occupational classification may lead to alternate categories for an analysis of the knowledge requirements of electronic technicians. Roneys' (1965, p. 2) comment on the divergence of views regarding classification was

> Two factors combine to complicate the process of identifying the occupational functions and educational needs of "highly skilled technicians in recognized occupations." One is the rapid expansion of the technologies, with the confusion of terminology and job classifications that has resulted. The second is the inordinate range of educational programs that have as their stated objective the training of "technicians."

The literature and research related to procedures for the analysis of knowledge requirements of electronic technicians was also examined with a view to adopting those procedures which appeared suitable for the present study. It has been recognized that research procedures which may be utilized for the study of occupations characterized more by knowledge than by skill may be expected to differ from those employed when the reverse situation prevails (Crocker, 1969, pp. 7-8). Rosenberg (1965, p. 47) stressed that

> First, there is the fact that the work world, including the processes of production, distribution, finance and control is becoming increasingly characterized by cognitive functions rather than muscular skills.

In addition, the field of employment for electronic technicians may be considered quite broad. U.S. Office of Education, 1966, p. 1). The diversity of jobs within the field of employment prohibits the use of conventional job-analysis techniques, although such procedures may be considered suitable for analysis of trades occupations (Crocker, 1969, pp. 7-8). This view was shared by Roney, (1965, p. 170) who stated that

> If occupational research is to be useful in improving instruction, the research should be directed toward the knowledge elements of the technician's job. It is not <u>what the technician does</u> that gives us insight to his educational needs; it is <u>what he knows</u>. Every student of trade and job analysis has at some time dissected a job to identify the necessary skills and related information. But an analysis of a technical occupation starts at a different point. We are primarily concerned with the technician's need for information and secondly with the ways in which he may use this knowledge - the applications.

Bjorkquist (1969, p. 182) suggested that a distinction may be made in terms of "field-oriented" programs as compared to "job-oriented" programs, he added that

> A job-oriented program centers on the development of skills and knowledges necessary for on-the-job performance. In a field-oriented program, emphasis is placed on the success of individuals in each of the courses offered so that application might be made to several occupations within the field of technology.

The analysis of knowledge requirements, then, may be expected to proceed along somewhat different lines depending on whether the program being studied falls within the "job" or "field-oriented" category.

Rating scales and interviews have been employed to obtain information pertaining to the knowledge and skill requirements of electronic technicians (Vasek, 1967; Weede, 1967). Recent use has been made of Q-methodology to obtain similar information (Crocker, 1969, Barlow and Schill, 1962; and Schill and Arnold, 1965). The literature related to Q-methodology, therefore, was examined for application to the study of knowledge requirements of electronic technicians in Alberta Industry.

III. OCCUPATIONAL CLASSIFICATION

Whitworth (1969, p. 14) indicated that there is no single "natural" set of categories to which all occupations belong. Various factors such as economic factors, personal characteristics, and abilities, social prestige or status, length and kind of training have been employed

to classify occupations. To a large extent, such systems of classification depend upon the purposes or uses to which the information will be put. This view was reflected by Baruch, (1941, p. 15) who stated that

> In order to classify any aggregation of things we must decide beforehand what the basis of classification will be. Naturally, this basis will be a quality or attribute in respect to which the things are alike or different. The selection of the particular basis to be employed in a given instance depends, therefore, on the purpose of the classification and the uses to which it is to be put. Different purposes usually require different bases of classification.

The development and evolution of modern systems of classification may be traced to the work done by American workers engaged in the collection of census data. According to Scoville (1969, p. 5) such classification schemes were primarily based upon the social and economic class structure of the United States. Nevertheless the purpose of the census classification was broad in scope and provided useful information related to the industrial distribution of the labor force. Such groupings according to Scoville (1969, p. 6), however, had very little relevance to the question of type and level of work performed.

A further improvement and somewhat more refined system of classification was provided with the introduction of the first edition of the Dictionary of Occupational Titles. The development of the Dictionary of Occupational Titles provided a description of work done under various occupational categories and was primarily aimed at officers of The United States Employment Service. The third edition of the Dictionary of Occupational Titles published in 1965 contains not only information about the duties and functions of workers engaged in various occupations but also lists the "worker-traits" required. The arrangement has been des-

cribed as follows

> The occupations in the Dictionary have been incorporated into a classification structure in which the individual occupations are identified by 6-digit code numbers which are used by the public employment service for classifying applicants and job openings, selection, reporting, and other operating purposes. The structure consists of two arrangements of jobs - the Occupational Group Arrangement and the Worker Traits Arrangement. These provide (1) a method of grouping jobs having the same basic occupational or worker trait characteristics so that the user can discern various relationships among occupations, and (2) a standard approach to classifying the abilities, vocational experiences, and/or potentials of workers.
>
> (Dictionary of Occupational Titles, 1965, p. XVI.)

Nine broad occupational categories form the basis for the classifications. The first digit indicates the broad divisions employed. These categories are further divided into eighty-four 2-digit divisions and finally into 603 distinctive 3-digit codes.

The second three digits of the six digit code number specify the worker trait requirements. The worker trait requirements have been described first in terms of the workers relationship to Data, People and Things, and second in terms of the highest appropriate function performed by the worker along the hierarchy from simple tasks to complex tasks. Taken together the last three digits of the code number can express the total level of complexity at which the job requires the worker to function. The system of classification employed in the Dictionary of Occupational Titles has been broadly defined since it must provide the means for classifying a wide spectrum of separate and distinct jobs within the entire economy of the United States.

The underlying model employed in the Dictionary of Occupational Titles to describe worker traits was developed by Fine (1964) and has been referred to as Functional Job Analysis. Functional Job Analysis has been

criticized by Scoville on the basis that

> Measurement of involvement with data, people, and things was undertaken originally for its value in placement; the transferability of this concept to other problems is unclear. This method ignores the contributions of the particular technical, functional, or material focus at the content of the job. Its relevance to economic and technological questions of training, wage structure, and worker movement may therefore be sharply limited.
>
> (Scoville, 1969, p. 10)

The manner of presenting information in the Dictionary of Occupational Titles has also come under criticism from Blaug (1967, p. 43), who suggested that

> We conclude that occupations must be defined in terms of the nature of the job, without any reference to the characteristics of the people who will or should take them up. Unfortunately, occupational census classifications, such as those adopted by the General Register Office (1960) Classification of Occupations, or the American Dictionary of Occupational Titles, do not satisfy this criterion. For a variety of historical reasons, these censuses classify occupations partly by job content, partly by the type and level of skill required to carry out the job, and partly by the social-prestige rating of the work performed; in other words, occupations are in some measure defined by the types of people commonly observed in them.

Blaug et al (1967, p. 42), take particular exception to the use of "educational qualifications" as a defining parameter of job structure since this 'would preclude asking any questions about the optimum utilization of educated people'. They stated that, "if an engineering occupation is simply all jobs held by people with engineering education, any questions about trained engineers working as salesmen, or technicians designing and constructing machinery are ruled out by definition." (Blaug, 1967, p. 4) Crocker (1969, p. 16) supports this view by indicating that if educators were to define technicians as those persons who had obtained a diploma in, say, electronics technology, then the "job requirements will have become defined in terms of a curriculum which has become established." The de-

pendency thus becomes reversed, resulting in an acceptance of the status-quo as far as the curriculum is concerned. Parnes, (1962, p. 147) realizing this weakness, suggested that

> It is essential to examine briefly, the conceptual difference between a classification by occupation and a classification by educational qualification. The former focusses upon the function performed in the productive process, i.e. the particular configuration of tasks or operations that the worker is expected to perform. The latter, on the other hand, looks to the amount and kind of instruction and training that the individual has been successful in acquiring. Why these two classifying principles are related, they are clearly not the same thing.

The term "technician", then, may tend to become a convenient "label" for employers who seek persons possessing a particular level of competence, or a potential to perform successfully at a given job. A view advanced by Blaug et al (1967, p. 44) is that

> Perhaps, one reason why most occupational classificatory schemes include education and training among the criteria for grouping together occupations is the reluctance to face up to the difficulties of scientific 'job-specification' (a list of the abilities required of the person who is to perform the job successfully), and 'job-evaluation' (the process of determining the worth of one job in relation to another, without regard to personalities).

Thus, at least three dimensions of job structure appear warranted. The first of these would include a description of relevant tasks, duties, functions associated with the particular job or jobs under consideration. Scoville, (1969, p. 12) referred to this horizontal dimension of job structure under the heading of "job family", and stated that "a job family is defined by the material, equipment or functions about which the jobs in it are centered". The second, or vertical dimension may be characterized by the level of complexity of the tasks, duties, and functions that make up the job family. Fine (1964, p. 34), referred to the vertical dimension as the 'level of functioning' whereas Scoville (1969, p. 15) referred to it as 'job content level'. Scoville (1969, p. 15)

summarized the two aspects of job structure thus

> Finally, the creation of a system to summarize the technical foci of jobs and the various levels of content will be useful in analyzing training and educational requirements. As the structure of demand for goods and services changes, so will the associated job content. In addition, technological change will affect some sectors of the job structure more than others. In the framework of content, projected changes in markets and technology can be linked to the changes in the kind and level of training required.

The two principal dimensions of job-structure, then, provide a means of classifying technical occupations in terms of the content of these occupations. A third dimension has been suggested by Fine (1964), to provide a description of individual worker characteristics required. This dimension was characterized by the knowledge, skills and attitudes required by the workers for successful job performance. Crocker (1969, p. 2) described the educational requirements in a similar way by employing Bloom's taxonomy. Whitworth (1969, p. 15) indicated that

> Among recent proposals for devising a new classification two are somewhat similar. The first states that one be devised using Bloom's taxonomy and the second that Guilford's list of separate mental abilities be the basis. The taxonomy provides for three major domains or classifications; the cognitive, the affective and the psychomotor.

The results of efforts to define a suitable model of job structure such that "families of jobs" or "job clusters" may be defined, may be seen to have evolved from methods primarily based upon socio-economic status to methods primarily concerned with the content, level and individual components of the job and of workers occupying such jobs. The model of job structure, then, consists of three dimensions of equal importance to the determination of educational requirements of workers, these are (1) the tasks, duties, functions and responsibilities performed, (2) the level at which these tasks, duties, functions and responsibilities are

performed and (3) the knowledge, skills and attitudes required for successful performance of the tasks, duties, functions and responsibilities assigned to the incumbent.

IV. CLASSIFICATION OF ELECTRONICS TECHNICIANS

A number of writers have not chosen to separate the systems for classifying electronic technicians from those employed to classify technicians from a wider spectrum of engineering related occupations. In particular, a member survey conducted by the Ontario Association of Certified Engineering Technicians and Technologists and interpreted by Watson and Butorac revealed considerable sub group differentiation within the broad classification of engineering technician (Watson and Butorac, 1968, p. 95). Members were requested to identify their "position." The responses yielded a total of twenty six separate classifications among which were included the titles of administration, inspection, supervision, management, research and development production, operation sales and service, purchasing, teaching, and drafting (Watson and Butorac, 1968).

The authors attempted to employ education as a means of differentiating and classifying technicians; however, it was discovered that a distinction had to be made between formal education, work experience, additional training in special applied courses and on-the-job training (Watson & Butorac, 1968).

They observed that on-the-job training and upgrading is often a decisive factor in determining the changing status of the technician within the labour force. In addition, training of this kind may be expected to have a positive effect upon the technicians' future performance.

They concluded that, "In these conditions precise classification is extremely difficult." (Watson and Butorac, 1968) Three grades of technician were recognized by the authors, (1) "junior technician," (2) technician, and (3) technologist (Watson and Butorak, 1968). The grades were primarily distinguished from one another by making reference to the general education attainment of incumbents. According to Schill and Arnold (1965)

> "What is a technician?" became a difficult question because the term was used to describe a tremendously wide range of individuals in diverse work situations. It appeared that two criteria were used extensively: first, that of training and education; second and most general, that of function and skill level.

The job functions employed in the study conducted by Schill and Arnold were coded according to: (1) Research and Development, (2) Sales, (3) Production or (4) Maintenance. In addition, categories were also employed to denote the level of technicians. Schill and Arnold (1965) cite Dobrovolny's definition of technician level as

1. Engineering technician who works primarily in direct contact with creative engineering;
2. Industrial technician whose specialty is closer to the production facilities of industry;
3. Technical specialist who has developed a skill or facility, the use of which constitutes his major occupational function, and
4. Management personnel responsible for the work of one or more technicians .

Attempts to apply these definitions resulted in several situations where classification could not be achieved, the authors stated that

"The definition of level of employment leaves some room for doubt with the exception of the operationally defined technical category (Schill and Arnold, 1965)." Salary level was employed as a criterion of job level.

Schill and Arnold (1965) also found that "age, salary, and the length of time on the current job were all highly correlated with one another." They observed that

> . . . supervisors exceed the expected frequencies in the upper salary level brackets and fall below the expected frequencies on the lower end of the salary continuum, while the reverse is true of technical specialists. This is consistent with earlier remarks that the basic entry job for the younger men coming into the technologies is in the repetitive type of job, as technician specialists.

The preceding job classifications schemes have in common the characteristic that both job function and job level appear frequently as dimensions of job classification schemes. To some extent educational qualifications possessed by job incumbents, or the level of skill or training required for successful job performance, were also employed for the purpose of classifying the work done by technicians.

The classification schemes used for technicians of various types were employed by Crocker (1969), Schill and Arnold (1965) to study the knowledge requirements of electronics technicians. Modifications were introduced, however, to take into account the specializations within the broader field of electronics as a whole. Barlow and Schill, for example, focussed upon the, "electronic technicians", as a particular group. The study by Barlow and Schill (1962) aimed at the identification of, "mathematics the technical worker actually used, or needed to have knowledge of, on the job." The classification scheme employed by Barlow and Schill (1962) required the following categories:

(1) Testing

(2) Field Service

(3) Plant Maintenance

(4) Instrument Maintenance

(5) Research and Development

(6) Design Drafting

(7) Communications

(8) Computers

(9) Radio-Television

According to Crocker (1969) the classification was limited by the fact that it employed a mixed variable classification scheme. That is, both job function and equipment had jointly been used to form the categories under investigation. Crocker (1969) on the other hand, employed a classification scheme which separated the equipment variable from that of job function . He proposed the following categories for the type of work variable:

1. Research and development (including design and testing of prototypes)
2. Production
3. Maintenance
4. Installation
5. Calibration and Standardization
6. Operation
7. Sales
8. Supervision
9. Others

He proposed the following for the type of equipment variable:

1. General electronics (including audio equipment, basic amplifiers, etc.)

2. Broadcast (radio and television)

3. Communications (VHF and UHF equipment etc., not included in 2)

4. Telephone Switching

5. Microwave

6. Navigational Aids (including radar)

7. Computers

8. Automatic control systems and industrial electronics

9. Others

The classification system visualized by Crocker (1969) required two categorical variables. The first variable enabled technicians to be grouped by job function, the second grouped technicians according to the equipment variable.

A classification system designed along similar lines was developed by the Federal Department of Labour -- Technical and Vocational Training Branch (1965). The system employed provided a description of the functional organization of the industry, the variety of the activities within the industry and the level of the various activities involved. The general pattern of the Electronics Manufacturing Industry and the breakdown of activities within one of the functional areas is shown in Appendix F. The descriptions for the various levels have been further classified in terms of the level of training required. Level I functions were associated with the recognized professions; Level II functions were associated with graduates of two year post secondary institutes; Level III functions were associated with the trades; and Level IV functions were associated with persons who require a few weeks to a few months on-the-job

training.

The classification by the Federal Government - Department of Labour of workers employed in the Electronics Manufacturing Industry was not subjected to experimental verification. Evidence was lacking, therefore, to confirm whether such categories exhibit distinctly different knowledge requirements.

V. Q METHODOLOGY

Schill and Arnold, (1965) Barlow and Schill, (1962) Crocker, (1969) Williams (1967) and others have demonstrated the application of Q-technique to the problem of assessing educational requirements of workers in technical occupations. The application of Q-technique as a means of facilitating comparisons between persons was indicated by Stephanson, (1936). His view was that

> If, then, any list of heterogeneous measurements or estimates can be arranged in an order of some kind, or in a scale, for their representativeness or significance for the individual, they may be held to be made homogeneous with respect to that individual.

In addition, Stephanson (1936) claimed that "once an order of significance has been identified for several individuals, the order may be compared with that of others." Cattell (1952) did not dispute this claim

> Q-technique has its chief use as a classificatory device for finding the sub populations in a non homogeneous population: . . . and for the special purpose of quantifying the extent to which an individual may be regarded as belonging to certain species and sub-species. Whether this can be considered a process of defining types depends upon the meaning one assigns to the term "type."

Summarizing the work of Stephanson, Wittenborn (1961) concluded that

> Q-methodology could include at least six points. (1) Q-method appears to require ipsative variables, particularly Q-sorts, (2)

> Q-method lends itself to correlations between people or between different conditions for the same person. (3) Q-method requires a conceptually structured set of statements in order to interpret the correlations between people . . . (4) Q-method permits a study of a person by means of analysis of variance of the statements . . . (5) Q-method favors dependency type emphasis in factor analyses . . and (6) Q-method leaves unanswered the question of the parent population from which the individual is drawn.

As a means for determining whether groups drawn from a population are more homogeneous than the population, Cronbach (1953) has recommended that "we need only examine the similarity measures for pairs within the group, compared to pairs drawn at random from the population."

The characteristics of the Q-Sort have been described by Mowrer (1953) who stated that, "The array of statements or items used in the Q-technique can be derived in any of a variety of ways . . ."

The forced choice sort in which the subject is required to sort items according to predetermined, more or less normal, distribution has been referred to by Mowrer (1953) as "Q-Sort." The subject must sort in such a manner that each pile or category contains a specified number of cards, where the number within each category, depends upon the total number of items and the number of categories specified. Each category represents a scale value from, say, "applys most" to "applys least." According to Mowrer (1953) the advantage to be gained by the sort technique include (1) the mean of the distribution automatically becomes the same for each subject, as does the sigma thereof, a fact which greatly simplifys the calculation of correlation coefficients.

The problem of "forced choice" versus "unforced" sorting procedures has, according to Wittenborn (1961) not been resolved. Block (1956) indicated that the forced sort method is superior or equal to free sorts.

Thus from the review of the literature it may be seen that electronic technicians may be classified according to the tasks, duties and functions they perform; to the level at which they perform these acts; and to the educational attainments required for successful performance. It may also be seen that the Q-sort technique has found practical use as a tool to assess the educational requirements of technicians. Its' main advantage in terms of the present study is that it allows for subjects to make a series of discriminations among items in terms of their utilization as perceived by the subjects, while also allowing for comparisons to be made between subjects or groups of subjects on the basis of the resulting sorts.

CHAPTER III

METHODOLOGY

I. INTRODUCTION

The purpose of the study was to examine the knowledge requirements of electronic technicians in Alberta Industry according to whether the technician occupied a high job level or whether he occupied a low job level. A review of the literature gave no evidence that job level had been employed as a major categorical variable for studying the knowledge requirements of electronic technicians. An instrument based upon the sort technique and consisting of knowledge items drawn from electronic curricula was used to examine the knowledge requirements of electronic technicians. Each knowledge item was rated according to level of generality along a five point scale. The instrument, developed by Crocker (1969), had previously been used for studying the knowledge requirements of electronic technicians classified according to major job function or type of equipment handled. The instrument developed by Crocker was employed in the present study to investigate the posssibility that differences existed between the level of generality of knowledge items required by electronic technicians who occupied high level jobs and those who occupied low job levels. Salary received by the electronic technician was used as a measure of job level in this study. A sort of the electronic knowledge items was obtained from each technician in response to the question "How often is the knowledge expressed in the card items used in your job?"

The study also sought to determine whether instructors at the Northern Alberta Institute of Technology would display different knowledge requirements than either of the technician samples.

II. PILOT STUDY

A pilot study involving five firms in the Edmonton area was conducted by the writer to obtain preliminary information on the administration of the card sort instrument employed in the study.

It was found that subjects responding to the instrument required, on the average, forty-five minutes to complete the card sort task. An additional fifteen minutes was required by subjects to complete the occupational and educational history questionnaire (Appendix B, pp. 72). All subjects were able to complete the card sort task. No problems were experienced by the writer in administering the instrument or the related questionnaire.

Data obtained from the pilot study were coded, punched on IBM cards, and subjected to one way analysis of variance designs for each category of the generality scale. The critical level of significance for all calculations was set a priori at 0.05. Data were processed on the 360 I.B.M. Computer at the Department of Computing Science, University of Alberta, using the one way analysis of variance program from the Division of Educational Research Services. Results obtained from the preliminary analysis revealed that while significant differences in mean utilization of knowledge items could be expected to occur between each of the technician groups classified according to job level and the instructor group at the Northern Alberta Institute of Technology, no evidence was obtained

to suggest that such differences would be likely to occur between the high job level and low job level technician groups.

On the basis of the pilot study, then, it was established that no changes would be made in either the instrument or the administration procedures connected with its use. It was also established that a total interview time of one hour was required.

II. DESCRIPTION OF THE SAMPLE

A list of Alberta firms which employed electronic technicians, at the time of the study, was compiled by the Alberta Bureau of Statistics and was used in the study to derive a representative sample of electronic technicians from within the province. The list of firms was compared with records of employers of electronic technicians maintained by the Edmonton Office of Canada Manpower as well as with a record of Alberta firms obtained from the Alberta Trade Index. The final list included all firms that were known to employ electronic technicians in Alberta. Where firms had Edmonton and Calgary offices, the Edmonton office was contacted to provide a sample. A letter sent to each employer indicated the nature of the study and requested the firms cooperation. Subsequently, the firm was contacted by telephone and arrangements were made for the interview.

The number of technicians contained in the sample selected from each firm was governed by the schedule set forth in Table I (p. 12). A limit of fifteen was adhered to so as to avoid the possibility of selecting too large a number of technicians from any one firm. Although the objective was to obtain a random sample of technicians this could not be assured in every case since on more than one occasion the immediate supervisor elected to select the technicians. Only electronic technicians

TABLE II

SUMMARY OF RESPONSES FROM

FIRMS EMPLOYING ELECTRONIC TECHNICIANS

Number of firms contacted	26
Number of firms that agreed to participate	21
Number of firms that declined to participate	4
Number of firms used in the study	13
No reply	1
Number of technicians interviewed	71
Number of technicians used in the sample	60
Number of Northern Alberta Institute of Technology Instructors interviewed	12
Number used in sample	11
Number of card sort response sheets discarded	12

conforming to the definition set forth in Chapter 1 were included in the study. No difficulty was experienced in determining whether the technician met the conditions of this definition. The responses by individual firms that comprised the sample are summarized in Table II.

III. INSTRUMENTATION

This study utilized a seventy-one item card sort developed by Crocker (1969). Each 2" x 4¼" card contained an item of subject matter in electronics. The items included in the instrument were balanced according to major topics representative of the field of electronics. Each knowledge item was independently rated by a panel of judges in terms of its level of generality. According to Crocker (1969) the resulting mean, rounded to the nearest whole number, was taken as the level of generality.

A measure of the reliability of the instrument was obtained by Crocker (1969) in terms of a sort-resort correlation, by having four electronic technicians repeat the sorts after an interval of approximately eight weeks. Content validity was obtained by having a panel of graduate students in electrical engineering and physics examine each of the items for errors.

During the interview session the subjects were required to complete a collection form to obtain additional information required for classification purposes. The following items of information were requested: (1) age, (2) highest high school grade completed, (3) salary, (4) source of electronics training, (5) job history, (6) current job, and (7) level of supervision. The card sort task required approximately

forty-five minutes to complete. The entire interview required approximately one hour.

Subjects were instructed that their anonymity would be preserved. Names were not required on the collection form which accompanied the card deck nor on the card sort response sheet. It was intended that the subjects response be unaffected by any concern that such information would be released to their employer.

Subjects were instructed to begin by sorting the items into three piles according to the question: "How often is the knowledge expressed in the card items used in your job either directly or indirectly?" The preliminary sort proved to be of benefit to subjects who experienced difficulty in making finer discriminations among items. One subject was unable to discriminate beyond the three preliminary piles and it was necessary to have the subject distribute the cards from each pile to the nine categories present in the card sort response sheet (Appendix B, pp. 72 without further discrimination.

After the subjects had completed the preliminary sort they were instructed to consider each pile in turn, beginning with the pile of most required items and ending with the pile of least required items. They were then instructed to sort the cards into nine categories ranging from most required to least required. The number of cards placed in each category was limited (Appendix B). Subjects were requested to discriminate between items in adjacent piles rather than within individual piles and were encouraged to make any corrections necessary at any time during the sorting procedure. The subjects were finally required to record the number in the upper left hand corner of each card, on the card sort response sheet. (Appendix B, pp. 72)

IV. ANALYSIS

The data obtained from the card sort response were coded and punched on I.B.M. cards. A program developed by the Division of Educational Research Services was utilized to compute weighted averages for each subject for each level of generality. One-way analysis of variance designs were performed for each level of generality between the high job level and the low job level technicians, and between each technician group and the instructor sample from the Northern Alberta Institute of Technology. F values were obtained to test for significant differences between sample means.

The data were processed on the I.B.M. 360 Computer at the Department of Computing Science, University of Alberta, using one program designed specifically for computing weighted means of the generality scores and a second program for the one way analysis of variance designs used in the study.

The detailed statistical procedures employed are set forth in Chapter IV under each hypothesis tested.

CHAPTER IV

PRESENTATION OF THE FINDINGS

I. INTRODUCTION

The purpose of this study was twofold. The first, the purpose was to investigate whether electronic technicians in Alberta Industry classified as high job level or low job level on the basis of salary received differed in mean utilization of electronic knowledge items. The second, the purpose was to investigate whether each technician group, so classified, and electronic instructors at the Northern Alberta Institute of Technology differed in mean utilization of electronic knowledge items. Four hypotheses were developed.

Hypothesis I was concerned with the variation, if any, between the mean utilization perceived by each group of electronic technicians for electronic knowledge items within each category of the five point generality scale. Hypothesis II sought to determine if there was a significant difference in the way the high job level electronic technicians and the electronic instructors perceived the relative utilization of electronic knowledge items. Hypothesis III sought to determine whether there was a significant difference in the way the low job level electronic technicians and the electronic instructors perceived the relative utilization of knowledge items. Hypothesis IV was concerned with the relating of a difference, if any, in Hypothesis I to the secondary variables of age, amount of formal education, number of years of related work experience and source of technical training.

A description of the instrument employed to obtain the data necessary to test these hypothesis is provided in Chapter III. Interview procedures used by the investigator were also outlined in Chapter III. A card sort, consisting of electronic knowledge items formed the basis for the data collection instrument used in this study. The resulting card sort together with selected classification variables constituted the data used in the analyses. Statistical procedures used in the study are also presented in Chapter III.

This Chapter restates the hypotheses to be tested, describes the methods of testing the hypotheses and presents the results in tabular and graphical form. Tabulation of item response frequencies for each technician group and for the instructor group within each utilization category is contained in Appendix G. The critical level of significance for all calculations in the study was set a priori at 0.05.

II. BETWEEN GROUPS ANALYSIS

Testing of Hypothesis I

This Hypothesis stated

> There will be no significant difference between high job level electronic technicians and low job level electronic technicians from Alberta Industry in mean utilization assigned to knowledge items within each category of a five point generality scale.

In order to obtain a comparison, twenty-six electronic technicians classified as high job level technicians and thirty-four electronic technicians classified as low job level technicians, according to the salary they received, responded to the seventy-one item electronic knowledge card sort. Cards were sorted by the subjects into nine categories ac-

cording to the relative utilization of each knowledge item as perceived by the subject when asked, "How often is the knowledge expressed in the card items used in your job either directly or indirectly."

Since the analysis of variance program required a unique score for individual technicians on levels of generality, it was necessary to first obtain a weighted mean utilization score for each technician on each level of generality. These scores were then used to compute the mean utilization for each technician group. Tabulation of the mean utilization for each technician group is shown in Table III. Values listed give the groups' mean utilization of electronic knowledge items for each generality scale value. The results obtained are shown graphically in Figure 1.

The two technician groups were compared on the basis of mean utilization for electronic knowledge items within each category of the five point generality scale for which category one contained the least general knowledge items and category five contained the most general by means of a series of one way analyses of variance. Results obtained are shown in Table IV. The significance of the difference between group means was tested by means of the F test (Ferguson, 1959, p. 234). Upon examining the results obtained it was found that there was no significant difference between the high job level electronic technician group and the low job level technician group on the basis of mean utilization of electronic knowledge items within each category of the generality scale with the exception of scale category five. The results of testing this hypothesis indicates that, with the exception of generality scale category five, the perceptions of the relative utilization of knowledge items contained in the sort were much the same for both groups of technicians.

TABLE III

HIGH JOB LEVEL AND LOW JOB LEVEL TECHNICIAN
MEAN UTILIZATION OF ELECTRONIC KNOWLEDGE ITEM
FOR GENERALITY SCALE CATEGORIES

Generality Value	High Job Level Technicians	Low Job Level Technicians	Difference Between Means
1	5.42	5.33	+0.09
2	5.06	4.87	+0.19
3	5.07	4.99	+0.08
4	4.83	4.98	-0.15
5	4.69	5.09	-0.40*

* Signifies a significant difference at the 0.05 level.

** Signifies a significant difference at the 0.001 level.

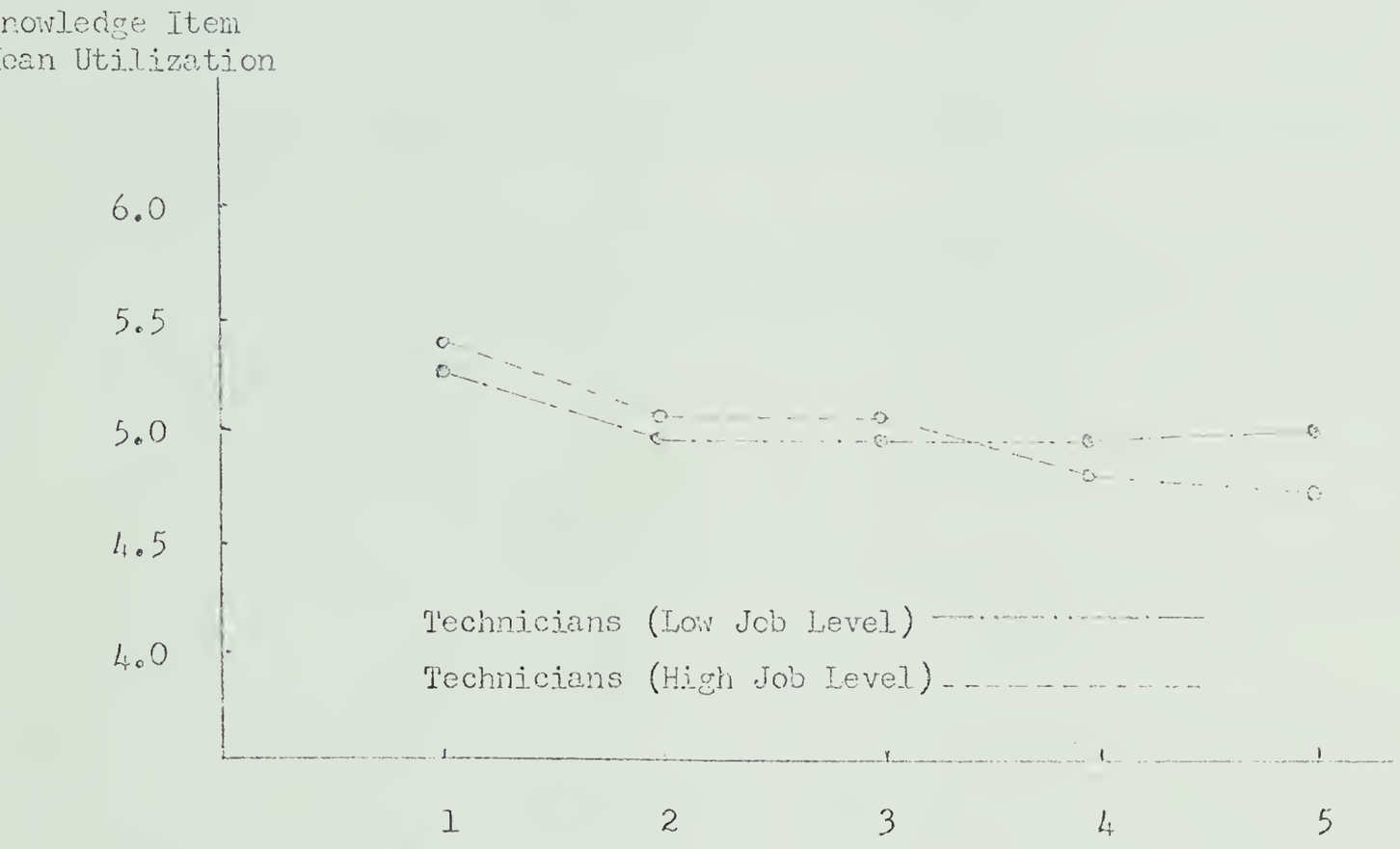

Figure 1

Mean utilization of electronic knowledge items for high job level electronic technicians and low job level electronic technicians by generality level.

TABLE IV

SUMMARY OF ANALYSIS OF VARIANCE FOR

TECHNICIAN GROUPS OVER UTILIZATION

SCALE CATEGORIES

Source of Variation	SS	MS	df	F	P
Generality Category 1 (Least General)					
Groups	0.10	0.11	1	0.18	n.s.
Error	33.73	0.58	58		
Generality Category 2					
Groups	0.57	0.57	1	2.69	n.s.
Error	12.33	0.22	58		
Generality Category 3					
Groups	0.09	0.09	1	0.85	n.s.
Error	6.13	0.11	58		
Generality Category 4					
Groups	0.36	0.36	1	2.20	n.s.
Errors	9.49	0.16	58		
Generality Category 5 (Most General)					
Groups	2.38	2.38	1	4.20	$<.05^{*}$
Error	32.83	0.57	58		

* Signifies a significant difference at the 0.05 level.

Testing of Hypothesis II

This Hypothesis stated

> There will be no significant difference between high job level electronic technicians and electronic instructors at the Northern Alberta Institute of Technology in mean utilization assigned to knowledge items within each category of a five point generality scale.

In order to obtain a comparison, eleven electronic instructors at the Northern Alberta Institute of Technology and thirty-four high job level electronic technicians from Alberta Industry who responded to the instrument sorted 71 cards into 9 piles on the basis of the extent to which the knowledge expressed on the cards was utilized either directly or indirectly in their jobs.

The weighted mean utilization was computed for each member of the technician group and each member of the instructor group within each category of the generality scale. Tabulation of the mean utilization, for each group within each category of the generality scale is shown in Table V. Graphical results obtained are shown in Figure two. One way analyses of variance were performed on each category of the generality scale using weighted mean utilization scores obtained for individuals within each group. The significance of the difference between group means was determined by means of the F test (Ferguson, 1959, p. 234). Tabulation of the results is shown in Table VI. Upon examining the results obtained, significant differences between mean utilization of knowledge items were obtained for generality categories one, two, and five. No significant differences in mean utilization of electronic knowledge items were obtained for generality categories three and four between the technician and instructor groups. The results of testing this hypothesis indicates

TABLE V

HIGH JOB LEVEL TECHNICIANS AND ELECTRONIC INSTRUCTOR MEAN UTILIZATION OF ELECTRONIC KNOWLEDGE

Generality Value	High Job Level Technicians	Electronic Instructors	Difference Between Means
1	5.42	4.83	+0.59*
2	5.06	4.44	+0.62**
3	5.07	5.15	-0.08
4	4.83	4.98	-0.15
5	4.69	5.75	-1.06**

* Signifies a significant difference at the 0.05 level.

** Signifies a significant difference at the 0.01 level.

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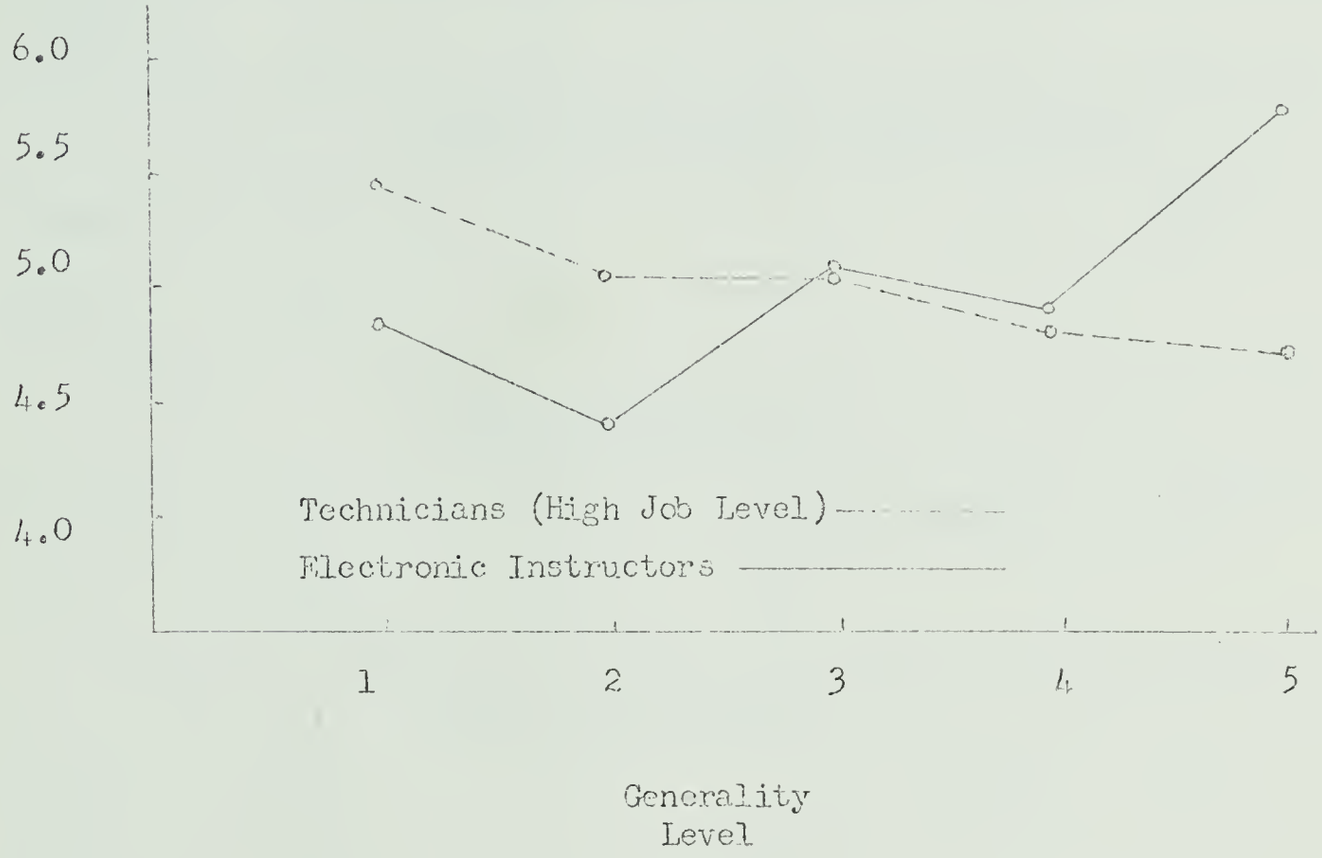

Figure 2

Mean utilization of electronic knowledge items for high job level electronic technicians and electronic instructors by generality level.

TABLE VI

SUMMARY OF ANALYSIS OF VARIANCE FOR

INSTRUCTOR AND HIGH JOB LEVEL TECHNICIANS

OVER UTILIZATION SCALE CATEGORIES

Source of Variation	SS	MS	df	F	P
Generality Category 1 (Least General)					
Groups	2.83	2.83	1	4.30	$<.05^{*}$
Error	28.29	0.66	43		
Generality Category 2					
Groups	3.23	3.23	1	15.53	$<.001^{**}$
Error	8.95	0.21	42		
Generality Category 3					
Groups	0.05	0.05	1	0.82	n.s.
Error	2.72	0.06	43		
Generality Category 4					
Groups	0.19	0.19	1	1.90	n.s.
Errors	4.40	0.10	43		
Generality Category 5 (Most General)					
Groups	9.36	9.36	1	16.91	$<.001^{**}$
Error	23.81	0.55	43		

* Signifies a significant difference at the 0.05 level.

** Signifies a significant difference at the 0.001 level.

that the perceptions of the relative utilization of knowledge items contained in the sort differed for both the highest generality category and for both of the low generality levels. No significant difference in perception of the relative utilization of knowledge items occurred for generality categories 3 and 4. Therefore, one could infer that high job level technicians perceived a higher mean utilization for items contained in the least general categories while instructors perceived a higher mean utilization for knowledge items contained in the most general category.

Testing of Hypothesis III

This Hypothesis stated

> There will be no significant difference between low job level electronic technicians and electronic instructors at the Northern Alberta Institute of Technology in mean utilization assigned to knowledge items within each category of a five point generality scale.

In order to obtain a comparison, a sample of eleven electronic instructors at the Northern Alberta Institute of Technology and twenty-six low job level electronic technicians from Alberta Industry responded to the sort instrument in the same manner as had the high job level electronic technician group. Weighted mean utilization scores were obtained for each subject within each category of the generality scale. The mean utilization was computed for each group within each category of the generality scale. Tabulation of the results obtained is shown in Table VII. Graphic results obtained are shown in Figure 3. One-way analyses of variance were performed on each category of the generality scale using weighted mean utilization scores obtained for individuals within each group. The significance of the difference between mean utilization values obtained by each group was tested by means of the F

TABLE VII

LOW JOB LEVEL TECHNICIANS AND ELECTRONIC INSTRUCTOR MEAN UTILIZATION OF ELECTRONIC KNOWLEDGE

Generality Value	Low Job Level Technicians	Electronic Instructors	Difference Between Means
1	5.33	4.83	+0.50
2	4.87	4.44	+0.43*
3	4.99	5.15	-0.16
4	4.98	4.98	-0.00
5	5.09	5.75	-0.66*

* Signifies a significant difference at the 0.05 level.

** Signifies a significant difference at the 0.001 level.

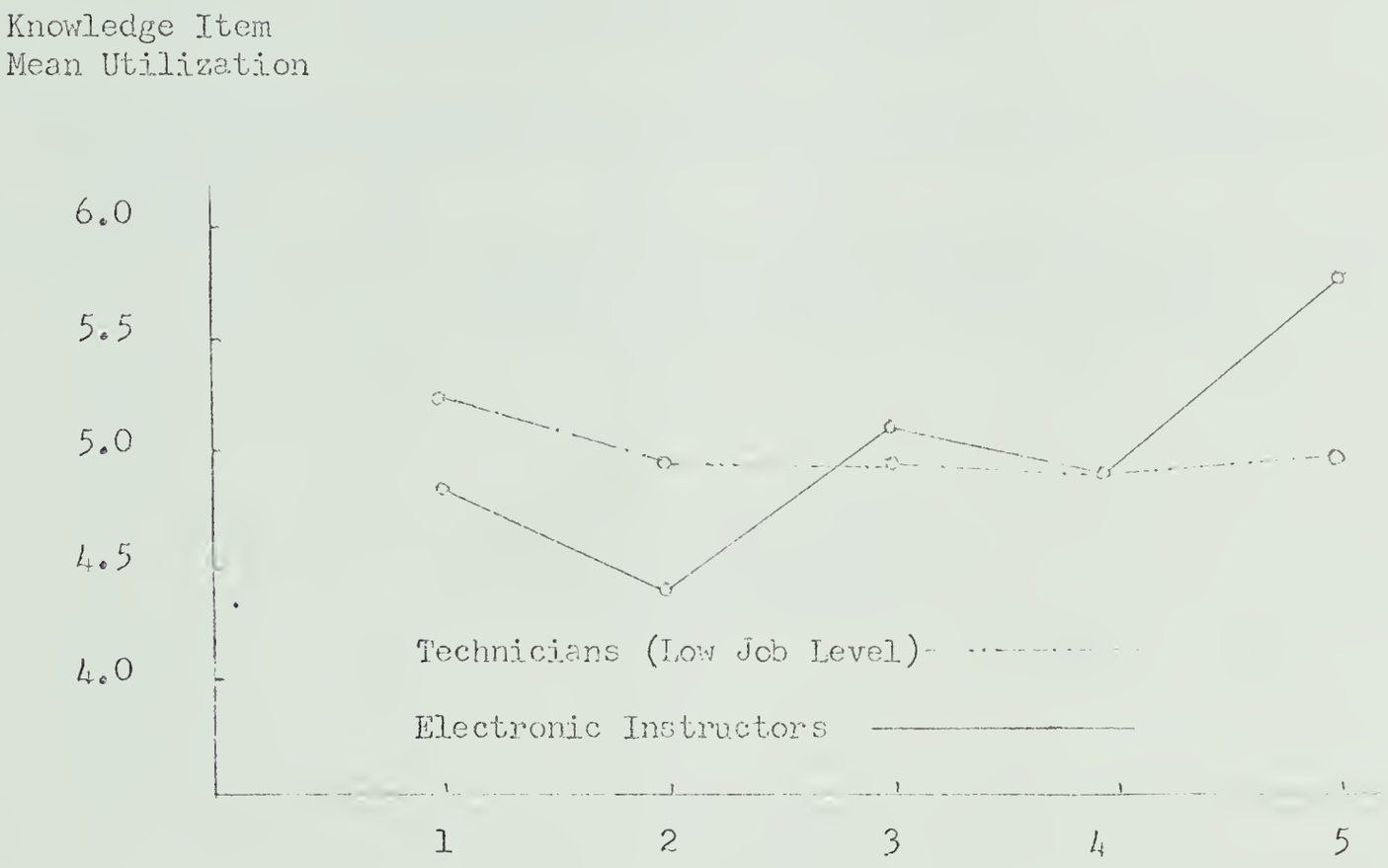

Figure 3

Mean utilization of electronic knowledge items for low job level electronic technicians and electronic instructors by generality level.

TABLE VIII

SUMMARY OF ANALYSIS OF VARIANCE FOR

INSTRUCTOR AND LOW JOB LEVEL TECHNICIANS

OVER UTILIZATION SCALE CATEGORIES

Source of Variation	SS	MS	df	F	P
		Generality Category 1 (Least General)			
Groups	1.93	1.93	1	3.80	n.s.
Error	17.78	0.51	35		
		Generality Category 2			
Groups	1.41	1.41	1	6.05	$<.05^{*}$
Error	8.15	0.23	35		
		Generality Category 3			
Groups	0.19	0.19	1	1.61	n.s.
Error	4.08	0.12	35		
		Generality Category 4			
Groups	0.0	0.0	1	0	n.s.
Errors	6.83	0.20	35		
		Generality Category 5 (Most General)			
Groups	3.37	3.37	1	5.65	$<.05^{*}$
Error	20.86	0.60	35		

* Signifies a significant difference at the 0.05 level.

** Signifies a significant difference at the 0.001 level.

test (Ferguson, 1959, p. 234). Tabulation of the results is shown in Table VIII. The results obtained were examined for significant difference between mean utilization of knowledge items within each category of the generality scale. Significant differences were obtained between the low job level electronic technician group and the electronic instructor group on the basis of mean utilization of electronic knowledge items for generality categories 2 and 5 only. No significant differences were obtained for generality categories 1, 3 and 4. The results of testing this hypothesis indicates that the relative utilization of knowledge items as perceived by the two groups of subjects differed for the highest generality category as well as for generality category 2, whereas no significant differences were obtained for generality categories 1, 3 and 4. Rejection of the hypothesis for generality categories 2 and 5 indicates that the low job level technicians perceived a higher mean utilization for one of the categories containing knowledge items of low generality whereas instructors perceived a higher mean utilization for knowledge items contained in the most general category.

Testing of Hypothesis IV.

This hypothesis, stated

> If a difference is found to exist between the groups used in the testing of Hypothesis I, is this difference related to the variables of:
>
> (a) age
> (b) amount of formal education
> (c) number of years of related work experience, and
> (d) source of technical training

Since a significant difference in mean utilization for generality category five was obtained for the two technician groups used in the testing of Hypothesis I, the data obtained from the knowledge item sorts

were subjected to further analyses. In order to obtain comparisons for each of the secondary variables stated in Hypothesis IV, the low job level and high job level technician groups were further subdivided on the basis of each of the secondary variables. Two-way analyses of variance were employed and the significance of the difference between mean utilization values were tested by means of the F test (Ferguson, 1959, p. 251). Tabulation of the results obtained is shown in Tables IX and X. The results obtained were examined to determine whether significant differences in mean utilization were related to such factors as the technicians' age, amount of formal education, number of years of related work experience and source of technical education.

Subgroups were formed on the basis of age by using the mean age thirty as the dividing point. No significant difference in mean item utilization was obtained between the groups formed on the basis of age, nor was a significant difference in mean item utilization obtained on the basis of an interaction between the technicians' age and the job level he occupied.

Subgroups were formed on the basis of the amount of formal education by having technicians who possessed less than an Alberta grade twelve standing form one group and those who possessed an Alberta grade twelve standing or higher form the other. The groups were further subdivided on the basis of the job level occupied by the technician. A two way analysis of variance was performed using weighted mean utilization scores obtained for subjects within each of the four subgroups. Tabulation of the results is shown in Table X. Upon examining the results obtained, no significant difference was obtained for mean item utilization between

groups classified on the basis of formal education, nor was a significant difference in mean item utilization obtained on the basis of an interaction between the formal education possessed by the technician and the job level he occupied.

The effect of the number of years of related work experience possessed by the technician upon the weighted mean item utilization perceived by the technician was tested by forming subgroups on the basis of the years of related work experience as well as the job level occupied by the technician, then subjecting the resulting mean item utilization values to a two-way analysis of variance. Groups were formed on the basis of technicians who possessed less than fifteen years of related work experience and those who possessed more than this amount. The results obtained are shown in Table X. Upon examining the results obtained, no significant difference in mean item utilization was obtained on the basis of the related work experience classification nor was a significant difference obtained as a result of an interaction between the job level occupied by the technician and the amount of related work experience he possessed.

In order to test the effect of the source of the technicians's technical training upon the weighted mean item utilization perceived by the technician four subgroups were formed. A division was made between electronic technicians who possessed technical institute training and electronic technicians who did not. The resulting weighted mean item utilization values were subjected to a two-way analysis of variance. Tabulation of the results obtained is shown in Table X. Upon examining the results obtained, no significant difference in mean utilization was

TABLE IX

SUMMARY OF ANALYSIS OF VARIANCE

FOR HIGH JOB LEVEL AND LOW JOB

LEVEL TECHNICIANS FOR GENERALITY CATEGORY 5

Source of Variation	SS	df	MS	F	P
		Age			
Job Level	2.64	1	2.64	4.564	<.05*
Age	0.28	1	0.28	0.482	n.s.
Interaction	0.19	1	0.19	0.336	n.s.
Error	32.36	56	0.58		
		Education			
Job Level	0.33	1	0.33	0.544	n.s.
Education	0.03	1	0.03	0.052	n.s.
Interaction	0.52	1	0.52	0.845	n.s.
Error	34.33	56	0.61		

n.s. means that the difference is not statistically significant.

* Signifies a significant difference at the 0.05 level.

** Signifies a significant difference at the 0.001 level.

TABLE X

SUMMARY OF ANALYSIS OF VARIANCE

FOR HIGH JOB LEVEL AND LOW JOB

LEVEL TECHNICIANS FOR GENERALITY CATEGORY 5

Source of Variation	SS	df	MS	F	P
		Related Job Experience			
Job Level	2.42	1	2.42	4.149	<.05*
Related job experience	0.08	1	0.08	0.130	n.s.
Interaction	0.02	1	0.02	0.031	n.s.
Error	32.74	56	0.58		
		Source of Technical Training			
Job Level	2.10	1	2.10	3.97	n.s.
Source of training	1.17	1	1.17	2.21	n.s.
Interaction	2.00	1	2.00	3.77	n.s.
Error	29.66	56	0.53		

n.s. means that the difference is not statistically significant.

* signifies a significant difference at the 0.05 level.

** signifies a significant difference at the 0.001 level.

obtained between the groups classified on the basis of the source of technical training. A difference approaching significance was obtained, however, for the groups classified on the basis of the source of technical training and the job level occupied by the electronic technician.

The results obtained in the testing of Hypothesis IV indicate that there were no significant differences in perceived mean utilization of electronic knowledge items contained within generality category 5 for the groups of technicians used in the testing of Hypothesis IV and classified on the basis of age, amount of formal education and number of years of related work experience. The results obtained for electronic technician groups classified on the basis of the source of the technicians' technical training indicate that there were no significant differences in weighted mean item utilization perceived by technicians classified on the basis of the source of the technicians' technical training; however, a difference approaching significance was found in weighted mean utilization between the technician groups classified on the basis of job level and source of technical training. Tabulation of the results of classifying the high and low job level electronic technician group by the secondary variables of age, amount of formal education, related job experience and source of technical technical training is shown in Table XI.

TABLE XI

CLASSIFICATION OF TECHNICIANS ON THE BASIS OF

SECONDARY VARIABLES

Group	Age (Years)		Salary		Range of experience (Years)		Source of Training		Education (Years)	
	Range	N	Range	N	Range	N	Source	N	Source	N
1	25^-	11	$\$6000^-$	6	4^-	15	Technical Institute	25	11^-	20
2	25-29	11	6000^- 6999	7	5-9	11	Other	35	12^+	40
3	30-34	15	7000^- 7499	13	10-14	17				
4	35-39	11	7499^- 7999	2	15-19	11				
5	40^+	12	8000^+	32	20^+	6				
Total		60		60		60		60		60
Median	33		$\$7500$		15				11	
Range	20-51		$\$3999^-$ - 9500^+		4^- - 20^+					

CHAPTER V

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

I. SUMMARY OF THE STUDY

Introduction and Purpose

This study attempted to determine whether there was a significant difference in the way electronic technicians who were classified as occupying high job level or low job level jobs utilized electronic knowledge. It was hypothesized that the way electronic technicians perceived the utilization of electronic knowledge items would be related to their job level. It was further hypothesized that electronic instructors and electronic technicians classified by job level would perceive the utilization of electronic knowledge items differently. Knowledge of this kind is required by educators of electronic technicians as an aid to better understanding of the characteristics of electronic technicians which, in turn, could contribute to an improvement in the technical program.

An instrument developed by Crocker (1969) was used in an effort to determine the relative utilization of knowledge items perceived by electronic technicians that were classified on the basis of job level. The instrument was also administered to eleven electronic instructors at the Northern Alberta Institute of Technology and sixty electronic technicians from Alberta Industry in an effort to determine whether instructors and technicians differed in their perception of the relative utilization of electronic knowledge items.

Subjects were required to sort seventy-one cards containing subject matter from the field of electronics (Appendix C) into nine categories according to the extent to which they perceived the relative utilization of the knowledge in their jobs. The instrument employed a five point generality scale wherein the most general knowledge items were assigned the value five and the least general knowledge items were assigned the value one. Items that possessed intermediate generality were assigned scale values two, three and four.

The weighted mean knowledge item utilization values for each person were subjected to one way analysis of variance. The F test was used as a test of significance.

II. CONCLUSIONS

This section restates the findings and discusses these findings in relation to the hypotheses. Implications and recommendations will be discussed with under headings of the same name.

Hypothesis I

This hypothesis stated that there will be no significant difference between high job level electronic technicians and low job level electronic technicians from Alberta Industry in mean utilization assigned to knowledge items within each category of the generality scale.

This hypothesis was not rejected on the basis of the results obtained from the analysis of 60 subjects for all generality categories with the exception of generality category 5. The hypothesis was rejected for generality category 5 on the basis of the results obtained from the analysis of 60 technicians.

Discussion of Hypothesis I

The results of the testing of this hypothesis indicate that, with the exception of the electronic knowledge items rated as most general, no significant difference in perceived mean utilization of electronic knowledge items existed between the groups of technicians used in the testing of this hypothesis. The assumption that high job level electronic technicians from Alberta Industry require more general knowledge than low job level electronic technicians appears unwarranted on the basis of the findings. The significant difference found to exist for generality category 5 will be dealt with under Hypothesis IV.

Hypothesis II

This hypothesis stated that there will be no significant difference between high job level electronic technicians and electronic instructors at the Northern Alberta Institute of Technology in mean utilization assigned to knowledge items within each category of a five point generality scale.

This hypothesis was rejected on the basis of the results obtained from the analysis of 40 subjects for generality categories 1, 2 and 5 and was accepted for generality categories 3 and 4.

Discussion of Hypothesis II

The results of the testing of this hypothesis indicate that no significant difference in perceived mean utilization of electronic knowledge items existed between the technician group and the instructor group used in the testing of this hypothesis for the intermediate levels of generality 3 and 4. The results obtained for generality categories 1, 2 and 5 indicate that the technician and instructor groups perceive differently

the mean utilization of electronic knowledge items at the extreme ends of the generality scale. The high job level electronic technician group obtained a higher mean utilization than the electronic instructor group for knowledge items classified as least general, while they obtained a lower mean utilization than the instructor group for knowledge items classified as most general. Crocker (1969) obtained similar results.

Hypothesis III

This hypothesis stated that there will be no significant difference between low job level electronic technicians and electronic instructors at the Northern Alberta Institute of Technology in mean utilization assigned to knowledge items within each category of a five point generality scale.

This hypothesis was rejected on the basis of the results obtained from the analysis of 37 subjects for generality categories 2 and 5 and was accepted for generality categories 1, 3 and 4.

Discussion of Hypothesis III

The results of the testing of this hypothesis indicate that no significant difference in perceived mean utilization of electronic knowledge items existed between the low job level technician group and the electronic instructor group used in the testing of this hypothesis for generality categories 1, 3 and 4. The results obtained for generality categories 2 and 5 indicate that instructors and low job level electronic technicians differ in perceived mean utilization of electronic knowledge items contained in generality categories 2 and 5. The mean utilization obtained by the instructor group was higher than that obtained by the

low level technician group for knowledge items contained within the most general category. Although no significant difference between means was obtained for the category containing the least general knowledge items, the technician group perceived a higher mean utilization for items in category 2 than did the instructor group.

Hypothesis IV

This hypothesis stated that if a difference is found to exist between the groups used in the testing of Hypothesis 1, is this difference related to:

(a) age
(b) amount of formal education
(c) number of years of related work experience, and
(d) source of technical training ?

No significant differences in mean item utilization were found on the basis of the results obtained from the analysis of 60 subjects for age, amount of formal education, number of years of related work experience and source of technical training. Differences in mean item utilization between groups on the basis of the interation between job level and each of the secondary variables were also not significant with the exception of the effect obtained for the job level occupied by the technician and the source of his technical training which, while not significant, very nearly approached the level required for significance.

Discussion of Hypothesis IV

The results of the testing of this hypothesis indicate that the significant difference in perceived mean utilization of electronic knowledge items obtained for generality category 5 between the two technician groups used in the testing of Hypothesis I could not be attributed to

age, amount of formal education, years of related work experience and source of technical training.

The results obtained for the effect upon mean item utilization of the interaction between job level and source of technical training approached significance at the 0.05 level. This would seem to indicate that low job level electronic technicians who had not obtained their technical training from an institute of technology perceived a higher mean utilization for more general knowledge items than did their high job level counterparts; while low job level electronic technicians who had obtained technical institute training perceived a lower mean utilization of more general knowledge than did their high job level counterparts. Other interaction results obtained were not statistically significant.

III. IMPLICATIONS

While the need to provide feedback between the employers of technicians and the training institutions is well recognized, the means to achieve such results for broad occupational areas such as electronics has not been the object of many research studies. Also, the educational needs of electronic technicians employed in highly specialized jobs must be taken into consideration in technical program development, while at the same time consideration must also be given to the development of knowledge which has wider application to the diversity of jobs available to the graduate. Classification systems provide a useful means of investigating the knowledge requirements of electronic technicians, however, existing systems of classifying jobs within the field of electronics appear to have placed limitations upon the development of information

of use to educators of technicians. The present study investigated the effect of job level upon the perceived knowledge utilization of electronic technicians. Knowledge of the educational requirements of electronic technicians has implications for curriculum planners, administrators and instructors. Such information has particular value for the development of technical curricula to meet the retraining and upgrading needs of adult workers. To realize the maximum value for studies of the type undertaken by the investigator the findings ought to be taken into consideration in the short term since technological change may be expected to render the results less useful over the long run.

IV. RECOMMENDATIONS

The study indicated that electronic technicians classified on the basis of job level did not differ significantly in perceived mean utilization of electronic knowledge items.

An exception was encountered, however, for one of the five levels of generality, namely the high job level electronic technician group perceived a lower mean utilization for general knowledge items contained within generality category five than did the low job level electronic technician group. Further investigation revealed a possible relationship between the mean knowledge item utilization perceived by the technician, the source of his training and the job level he occupied.

The findings of this research support the position that there is a need for a greater awareness by educators of the specialized knowledge requirements of electronic technicians. It would, perhaps, be unwise to recommend that the major emphasis in programs designed to prepare elec-

tronic technicians to enter industry be devoted to specialized topics, however, provision for greater specialization during the final months of training appears to be warranted. The inclusion of more specialized courses in the technical curriculum could also provide the means for adult technicians to return for retraining and upgrading. In addition, the provision of courses along these lines would create an opportunity for adult technicians to acquire the necessary training to shift between specialized jobs within the field of electronics. The need for these courses is particularly evident in a field such as electronics where technological change continually creates the need for extended training of technical personnel.

Suggestions for Further Research

1. Further research is required to clarify the relationship between the mean utilization of knowledge items, the technician's source of technical training and the job level he occupied for high job level and low job level groups.

2. Further research is also required to assess the technician's requirements for skills rather than knowledge. The development of a card-sort based upon laboratory exercises might prove to be a useful means for identifying skill requirements.

3. Further research into the views held by supervisors for the knowledge requirements of electronic technicians, perhaps, employing techniques other than Q-sort might be explored. An interview approach or questionnaire technique could be employed. Criteria other than salary could be used as a measure of job level.

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APPENDIX A

NORTHERN ALBERTA INSTITUTE OF TECHNOLOGY

May 29, 1970

Dear Sir,

As part of a continuing effort to keep programs of technical education relevant to the needs of Alberta Industry the present study, for which your cooperation is hereby requested, has as its' objective the determination of the educational needs of electronic technicians in Alberta. The study will require that approximately one hundred electronic technicians employed by Alberta Industry be randomly selected.

I would be most appreciative if your organization could make available sometime during the period June 1 to June 15th, 1970, approximately one to fifteen electronics technicians (schedule enclosed) for a duration of one hour. The task will consist of sorting cards containing subject matter from electronics curricula into categories which indicate their relative importance to the technician.

Certain other information concerning past experience, education, extent of supervisory experience and salary will also be collected at the time of the interview. This information will be employed for the purpose of classifying technicians. The analysis in turn will depend upon both the classification as well as the response to the card sort.

The information collected will be treated confidentially. Names of organizations and individuals will not be recorded. The resulting study, however, will provide information of use to those engaged in technical education here in Alberta.

I will be in contact, by telephone, with a representative of your organization to secure your assistance. If, however, you wish to contact me directly by telephone my number is 479-8471 local (348).

Yours truly,

C.A. Sammons, P. Eng.,
Electronics Department
Northern Alberta Institute of Technology

CAS/dm

SELECTION SCHEDULE

Total Technicians Employed	Number Selected
5 or less	1
6-10	3
11-25	5
26-50	8
51-100	12
more than 100	15

APPENDIX B

FORM A

EDUCATIONAL AND OCCUPATIONAL INFORMATION

1. ID Number _____ 2. Company ID _____

3. Age _____ 4. Highest High School Grade Completed _____

5. Salary Code See Form B _____

6. Electronics Training

Source	Time (months)
Technical Institute	_____
Armed Forces	_____
Company Programs	_____
Individual Study	_____
Other (specify)	_____ _____

7. Job History

List all jobs you have held related to electronics, including all different jobs with the present company. Jobs are to be described using the codes given on Form B. Jobs are to be considered as different if they can be described by different codes. If code 9 (other) applies, use the last column to describe the job. If more than one code number applies, use that which describes your predominant activity.

	Length of Employment (years)	Type of Work	Kind of Equipment	Other
1.	_____	_____	_____	_____
2.	_____	_____	_____	_____
3.	_____	_____	_____	_____
4.	_____	_____	_____	_____
5.	_____	_____	_____	_____
6.	_____	_____	_____	_____
7.	_____	_____	_____	_____
Present Job	_____	_____	_____	_____

8. If your present job has been classified as supervisory, give the approximate number of technicians under your supervision. _____

ID	C	A	P	E	TE	S	R	T	J1	J2	SU
☐☐☐	☐☐	☐☐	☐☐	☐☐	☐	☐	☐☐☐	☐☐	☐	☐	☐☐

I JOB CODES

Code	Type of Work
1	Research and Development (including design and testing of prototypes)
2	Production
3	Maintenance
4	Installation
5	Calibration and Standardization
6	Operation
7	Sales
8	Supervision
9	Other

Code	Kind of Equipment
1	General Electronics (Basic amplifiers, audio equipment, etc.)
2	Broadcast (radio and TV)
3	Communications (including VHF and UHF equipment not included in code 2)
4	Telephone switching
5	Microwave
6	Navigational aids including radar
7	Computers, data processing equipment
8	Automatic control systems and industrial electronics
9	Other

II SALARY CODES

1	$3999-
2	$4000-4499
3	$4500-4999
4	$5000-5499
5	$5500-5999
6	$6000-6499
7	$6500-6999
8	$7000-7499
9	$7500-7999
10	$8000-8499
11	$8500-8999
12	$9000-9499
13	$9500+

FORM C

CARD SORT INSTRUCTIONS

1. Cards in each deck are initially to be sorted into three piles in response to the appropriate question as given below. For the initial sort there are no restrictions on the number to be placed in each pile. The number of cards in each pile is to be entered in the box in the upper right hand corner of the appropriate reporting form.

2. The final sort is to consist of nine categories with each category having a fixed number of cards as indicated on the reporting forms. The simplest procedure is perhaps to take the three initial piles, starting with the most related pile, and begin sorting these into categories beginning with 9 and working downward until this pile has been exhausted. The middle pile can then be sorted beginning with the category in which the first pile ended. This procedure is continued until all cards are exhausted and all categories filled. It is suggested that adjacent categories then be compared as a check on whether perhaps the categories of some cards should be interchanged. Do not begin to write card numbers on the reporting form until you are satisfied that all cards are in their proper categories.

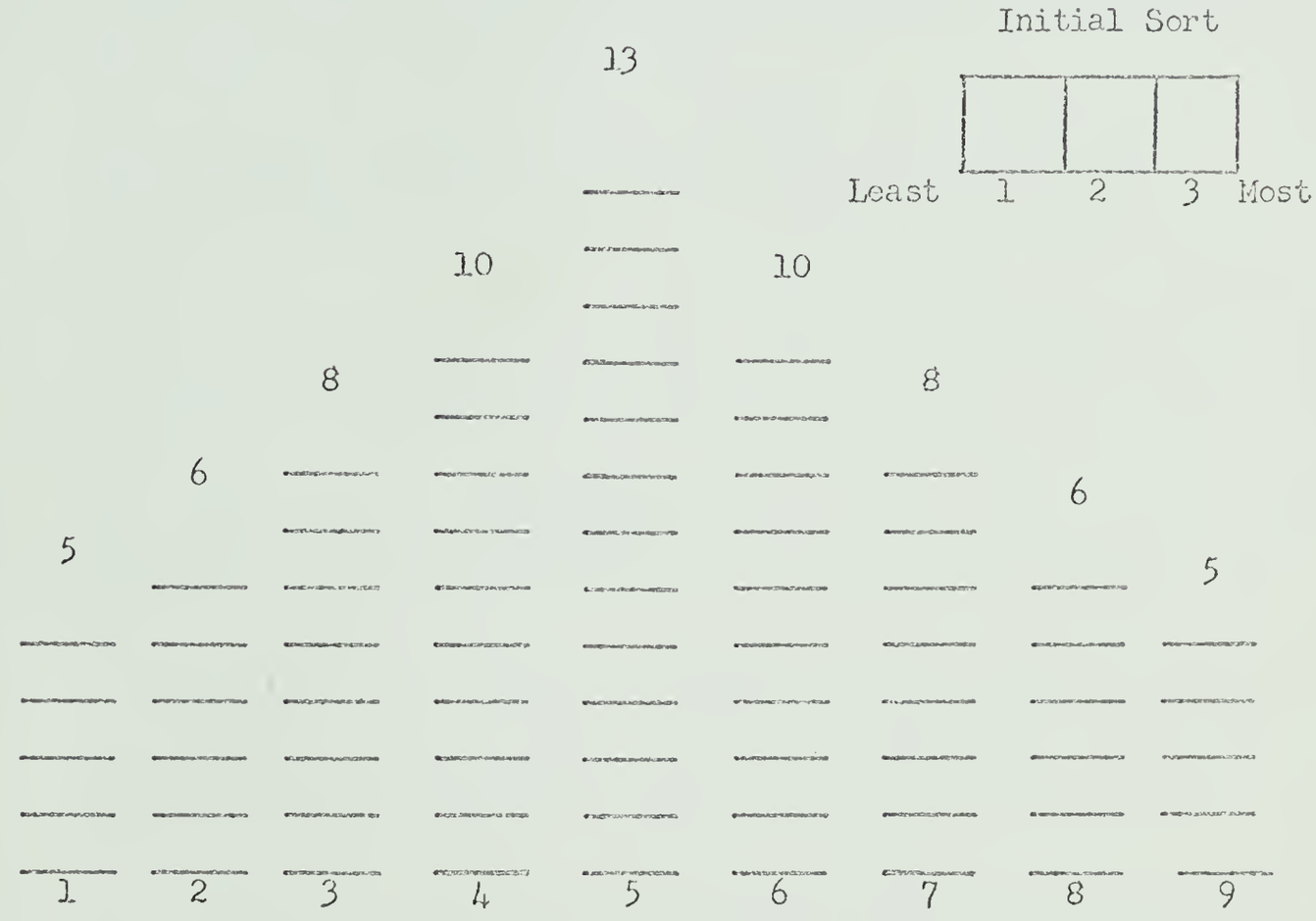
3. For the electronics deck (card numbers starting with 3) the question is: "How often is the knowledge expressed in the card items used in your job either directly or indirectly?"

ID _____

FORM D

ELECTRONICS SORT REPORTING FORM

(Number at top of each category
indicates number of cards in that category)



APPENDIX C

301 For small signal cases, a triode may be replaced by a linear equivalent circuit consisting of a voltage source equal to the amplification factor times the grid voltage, in series with the plate resistance.

302 In a cathode ray tube, electrons are deflected to different portions of the screen by the application of an electric or magnetic field at some point along the electron path.

303 A metal contains a relatively large number of high energy "free" electrons which may give rise to a flow of electrons upon the application of an electric field.

304 Electrons are emitted from a metal which has been heated to incandescence. These electrons may be subjected to controlled motions by the application of electric or magnetic fields.

305 Certain impurities when added to a semiconductor result in the existence of an excess or deficiency of free electrons, thus increasing the conductivity of the semiconductor.

306 In a vacuum diode, electrons are emitted from a hot cathode and accelerated towards an anode by the application of a possitive voltage to the anode. The diode thus is a conductor in only one direction.

307 In general the detection of an amplitude modulated signal requires that part of the RF signal be suppressed (i.e. by rectification) in order that the carrier may be filtered out while retaining variations at the frequency of the intelligence signal.

308 The small signal hybrid parameters of a transistor may be used in developing four terminal linear equivalent circuits for transistor amplifiers.

309 A potential barrier exists at the junction of a p-type and an n-type semiconductor, preventing conduction across the junction. The barrier may be raised or lowered by the application of external voltages of opposite polarities.

310 Certain substances have the property of emitting electrons when exposed to light.

311 Amplification in a triode is accomplished by the application of a small signal voltage to the grid which results in a large current variation in a load and a correspondingly large voltage variation.

312 A load line superimposed on the plate characteristic curves of a triode permits the calculation of operating conditions if the supply voltage, load resistance, and bias voltage are specified.

313 The small DC bias voltage required at the grid of a triode may be supplied by placing a resistor in either the grid or cathode circuit.

314 An emitter follower (grounded collector) transistor amplifier has high input impedance enabling it to be used in circumstances in which loading of the input signal source is undesirable. The current gain of such an amplifier cannot exceed one.

315 Amplification in a transistor is achieved by the transfer of a current change from a low resistance input circuit to a high resistance output circuit.

316 Biasing a transistor amplifier must involve precautions to prevent excessive currents which lead to thermal runaway.

317 In a typical transistor amplifier the collector-base junction is biased in the reverse direction (giving a high resistance) and the emitter-base junction is biased in the forward direction (giving a low resistance).

318 Pentode type tubes have the property that plate current is independent of plate voltage over a wide range.

319 Tubes containing small amounts of a gas may be made to conduct by the application of electric fields since these fields can cause ionization of the gas to provide free electrons. Typical uses for such tubes are in high power rectifiers, light sources, and voltage regulators.

320 The vacuum tube voltmeter avoids the problems of loading the system on which measurements are being made since the vacuum tube amplifier has an extremely high input impedance.

321 The design of filters is based essentially on the property that capacitors and inductors exhibit different impedances at different frequencies.

322 The coupling of amplifier stages requires that signals be transferred from stage to stage while isolating stages from non-signal effects such as biasing voltages.

323 In a class B amplifier (either tube or transistor) no output signal is obtained for part of the input signal cycle. For a class C amplifier output signal appears for less than half the input signal cycle.

324 The current-voltage characteristics of tubes and transistors are linear over only relatively narrow ranges. Thus for large signal cases the output signal may not have exactly the same waveform as the input signal.

325 Any complex waveform may be analyzed into sine wave components consisting of a fundamental frequency and multiples of this frequency. Distortion may thus be analyzed in terms of such components.

326 Maximum power transfer from a system (such as an amplifier or oscillator) to a load occurs when the impedance of the load equals the output impedance of the system.

327 The push-pull circuit reduces distortion by balancing out all even harmonics in the output.

328 The driver stage for a push-pull circuit is any circuit which can split the input signal into two parts which are 180 degrees out of phase with each other.

329 Negative feedback involves the feeding of part of the output signal back to the input 180 degrees out of phase with the input. Such feedback increases the stability of the amplifier at the expense of gain.

330 The operational amplifier is a special case of feedback amplifier which permits the output signal to be special functions of the input depending on the characteristics of the feedback network.

331 A feedback amplifier becomes an oscillator if the feedback signal is in phase with the input and the loss of signal in feedback is not greater than the gain of the amplifier.

332 A crystal has a characteristic resonant frequency which permits it to be used as a high quality tuned circuit for high frequency oscillators.

333 Ripple filters for power supplies rely on the energy storage properties of inductors and capacitors to smooth out pulsating voltages obtained from a rectifier.

334 RF amplifiers are generally designed to provide high gain over a narrow frequency range through the use of tuned circuits.

335 The superheterodyne receiver avoids the problem of simultaneous variable tuning of many circuits by converting the input signal to an intermediate frequency which may be amplified using fixed tuned circuits.

336 AM broadcast systems transmit intelligence by changing the amplitude of a high frequency carrier signal by an amount proportional to the amplitude of the intelligence signal.

337 FM broadcast systems transmit intelligence by changing the frequency of a carrier signal by an amount proportional to the amplitude of the intelligence signal.

338 FM systems have the advantage that high amplitude noise bursts can be suppressed without also suppressing useful information.

339 Radio broadcast systems of different frequencies have different ranges because of the different reflection characteristics of electromagnetic waves of various wavelengths when in contact with certain materials (such as the ground or the atmosphere).

340 Directional antennas are based on the inteference properties of electromagnetic waves for the reinforcement of waves in the desired direction and their suppression in undesired directions.

341 A bistable multivibrator (flip-flop) may be used as a switch since a pulse applied to one stage causes the other stage to change its state from conducting to non-conducting or the reverse.

342 In the image orthicon tube the beam from an electron gun is density modulated by a field resulting from variations of photoelectrons emitted at different points on a photosensitive plate.

343 The composite TV signal contains video and audio information as well as pulses for synchronization of the receiver.

344 In a TV picture tube the incoming video signal is used to modulate the intensity of the electron beam.

345 FM stereo broadcasting is achieved by transmitting the sum and difference of the two channel signals and the adding and subtracting of these signals at the receiver to recover separate channel signals.

346 Transducers are any devices which can be used to convert between electrical energy and other forms of energy.

347 Telemetry is based on the principle that transducers can convert other forms of energy into electrical signals characteristic of the original energy. These signals can then be used to modulate a carrier.

348 Single sideband communications requires close tolerences in filter and oscillator equipment since small frequency shifts cause relative large changes in the relation of carrier to sidebands.

349 The bi-stable multivibrator (flip-flop) may be used as the basic building block for devices which perform binary operations such as counting, bit storage or adding.

350 Small magnetic cores which may be magnetized in either a positive or negative direction by an electric current may be used to store information in binary form.

351 Color TV broadcast differs from black and white in requiring the transmission of three signals corresponding to the three primary colors. The relative strength of each signal determines the resultant color.

352 In the klystron tube a beam of electrons is velocity modulated by a small input microwave signal to produce a much larger signal at the same frequency.

353 Conventional circuits become inoperative at microwave frequencies because the small capacitances and inductances of terminals and leads introduce additional significant impedances.

354 A resonant cavity is resonant at any wavelengths which are integral multiples of the cavity length.

355 Control systems are based on the conversion of a deviation from the normal (error) into an electrical signal which can be amplified and used to drive a mechanical system designed to correct the error.

356 Complex switching operations may be carried out by the use of combinations of electromagnets or multivibrators. The automatic telephone exchange is an example of such switching.

357 Integrated circuits eleminate leads and terminals by making direct contact between components. This improves the high frequency characteristics of the circuits as well as reducing physical size.

358 The electronic analog computer uses combinations of operational amplifiers to produce an output which is a specified function of the input.

359 Radar involves the transmission of a pulse which is reflected from an object, the reflected signal being detected by the receiver and the time delay between transmitted and reflected pulse measured.

360 Maser action is based on the principle that molecules or atoms excited to a high energy level by an external energy source can be made to give up their energy by the application of a small amount of microwave energy.

361 A simple AND logic circuit consists of a transistor amplifier biased beyond cutoff and fed by a series of input signals such that an output signal appears only if a signal appears at all inputs.

362 If an electromagnetic wave is reflected from a moving object, the reflected wave shows a frequency change proportional to the speed of the object. The frequency change can be detected by combining the original and reflected waves and measuring the frequency of the resultant wave.

363 The magnetic amplifier uses a core magnetized to near saturation by DC current to exert control over a large AC current in a secondary winding. Near saturation a small DC change leads to a large change in the inductance of the coil.

364 High fidelity audio reproducing equipment has a nonlinear frequency response characteristic designed to reverse the nonlinearity in the recording characteristic.

365 In the general case, the amplitude and phase of the feedback signal in a feedback amplifier is a function of frequency. In designing such amplifiers it is therefore necessary to ensure that no frequency exists for which the feedback will be such as to produce oscillation.

366 The oscilloscope permits visual display of a voltage waveform by developing a continuous sweep of the beam in a cathode ray tube in a horizontal direction, while varying the vertical position of the sweep by the voltage whose waveform is to be observed.

367 A waveguide may be used to couple the antenna of a microwave system to the transmitter or receiver since the wavelengths of signals in the microwave region are of the same order of magnitude as the dimensions of practical apparatus.

368 If the reverse voltage across the junction of a semiconductor diode is sufficiently large, the few electrons which flow under reverse conditions may acquire sufficient energy to produce ionization by collision. The current under these conditions can become very large.

369 A synchro motor as used in servo systems is one in which the position of the rotor is a function of voltages applied to three stationary windings.

370 An amplitude modulated carrier signal is equivalent to a composite signal consisting of the carrier and the sum and difference frequencies (sidebands) between carrier and modulating frequencies. All information in the composite signal is contained in one of the sidebands.

371 In the Schmitt trigger the output circuit is in a conducting state only if the input signal is above a certain level. This circuit can thus be used to shape an arbitrary input signal into a square wave pulse.

APPENDIX D

TABLE XII

DEGREE OF GENERALITY 'G' OF

ELECTRONICS KNOWLEDGE ITEMS

Item	G	Item	G
301	4	336	4
302	4	337	4
303	5	338	2
304	5	339	4
305	4	340	4
306	3	341	3
307	3	342	1
308	4	343	3
309	3	344	3
310	5	345	3
311	4	346	5
312	3	347	3
313	2	348	1
314	1	349	3
315	4	350	2
316	2	351	2
317	3	352	2
318	2	353	4
319	4	354	4
320	1	355	4
321	5	356	3
322	2	357	1
323	3	358	4
324	3	359	3
325	5	360	3
326	3	361	1
327	3	362	2
328	2	363	2
329	4	364	2
330	3	365	4
331	3	366	2
332	4	367	3
333	3	368	3
334	3	369	2
335	3	370	5
		371	3

APPENDIX E

LIST OF PARTICIPATING ORGANIZATIONS

Canadian Department of Transport, Western Air Services Region

Canadian Forces Base, Namao

Canadian Broadcasting Corporation, Edmonton

Canadian Marconi Limited, Edmonton

CFRN Sunwapta Broadcasting Limited, Edmonton

Defence Research Establishment, Suffield

Edmonton Public School Board

International Business Machines, Edmonton

International Business Machines, Calgary

Northwest Industries Limited, Edmonton

Northern Alberta Institute of Technology, Edmonton

Pacific Western Airlines Limited, Edmonton

University of Alberta, Technical Services Division

Xerox of Canada Limited, Calgary

Xerox of Canada Limited, Edmonton

APPENDIX F

ELECTRONIC MANUFACTURING MANAGEMENT

ELECTRONIC COMPONENTS MANUFACTURING FACILITY

DOMESTIC CONSUMER PRODUCTS MANUFACTURING FACILITY

ELECTRONIC EQUIPMENT MANUFACTURING FACILITY

THE MANUFACTURE OF EACH PRODUCT ABOVE MAY REQUIRE SOME OR ALL OF THE FUNCTIONAL ACTIVITIES SHOWN BELOW

RESEARCH

PRODUCT DEVELOPMENT

MANUFACTURING PLANNING AND CONTROL

PRODUCT PRODUCTION

QUALITY CONTROL

PLANT ENGINEERING

PLANT ADMINISTRATION

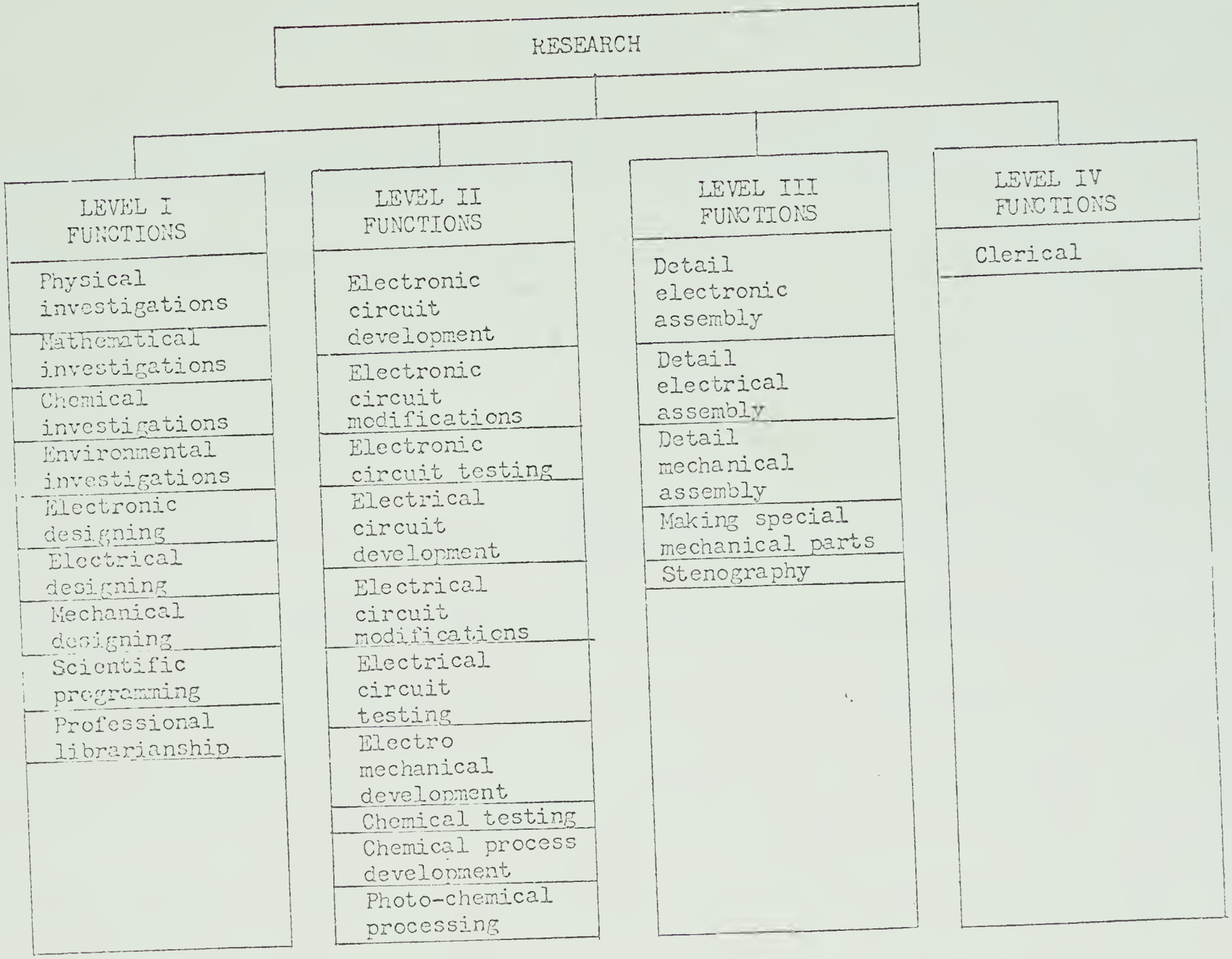
MATERIAL CONTROL, PURCHASING, DISTRIBUTION

MARKETING

SERVICE

ELECTRONICS MANUFACTURING INDUSTRY

GENERAL PATTERN



FUNCTIONAL ACTIVITIES - DETAILED BREAKDOWN

APPENDIX G

TABLE XIII

FREQUENCY DISTRIBUTION OF TECHNICIAN RESPONSES

	Utilization Category								
Item	1	2	3	4	5	6	7	8	9
301	5	3	10	15	17	5	1	3	1
302	1	2	2	6	15	12	10	6	6
303	4	7	8	13	13	8	4	1	2
304	1	7	9	12	12	8	8	1	2
305	6	3	8	9	11	13	7	1	2
306	2	2	3	3	16	12	11	7	4
307	2	1	8	10	16	3	7	9	4
308	4	6	11	12	18	7	1	1	0
309	1	1	2	9	12	17	7	6	5
310	5	11	9	10	8	7	6	2	2
311	1	1	3	5	8	18	10	11	3
312	3	7	8	12	20	4	3	2	1
313	0	3	5	6	14	9	11	9	3
314	0	0	2	6	12	15	13	9	3
315	2	0	2	5	9	21	11	7	2
316	1	0	1	7	14	11	11	9	6
317	1	0	0	7	11	15	12	8	6
318	3	0	6	16	18	7	6	2	2
319	1	4	7	13	14	12	5	3	1
320	0	0	0	2	5	18	9	9	17
321	2	0	1	6	14	11	16	6	4
322	1	1	4	3	12	11	14	8	6
323	0	1	1	12	21	7	13	3	2
324	0	1	3	13	20	12	8	2	1
325	2	2	2	14	17	10	7	4	2
326	0	1	2	3	12	12	13	9	8
327	0	0	6	15	17	7	8	4	3
328	1	0	6	6	16	15	5	5	6
329	1	0	0	9	9	14	14	6	7
330	2	0	11	8	10	7	10	6	6
331	1	0	1	14	17	12	10	5	0
332	1	1	6	10	8	6	10	13	5
333	0	0	1	8	9	12	13	13	4
334	1	4	6	9	13	7	7	6	7
335	1	9	11	6	9	4	5	8	7
336	4	10	9	13	6	7	6	3	2
337	6	5	19	6	8	10	3	2	1
338	6	6	11	8	11	7	6	1	4
339	4	10	16	7	7	6	5	3	2
340	5	8	4	9	10	7	10	5	2

TABLE XIII (continued)

Item	Utilization Category								
	1	2	3	4	5	6	7	8	9
341	2	1	3	9	7	6	9	12	11
342	17	16	5	3	5	5	2	2	5
343	6	15	10	7	9	2	1	3	7
344	5	13	9	8	5	4	6	6	4
345	10	14	13	10	7	6	0	0	0
346	5	6	9	5	12	6	10	3	4
347	16	12	8	4	8	7	4	0	1
348	4	6	11	7	3	7	6	5	11
349	4	3	7	7	10	6	8	6	9
350	13	10	10	6	9	2	2	4	4
351	10	15	11	6	7	5	0	1	5
352	8	11	15	5	8	5	0	7	1
353	6	9	7	13	7	8	3	6	1
354	6	7	11	14	4	8	3	6	1
355	4	3	6	7	13	8	8	4	7
356	7	7	10	11	10	8	3	1	3
357	2	4	6	13	12	6	5	10	2
358	9	6	15	9	7	4	2	5	3
359	13	6	6	8	7	3	2	3	12
360	26	13	8	6	3	4	0	0	0
361	6	3	6	10	11	5	5	8	6
362	7	12	8	10	6	7	3	3	4
363	6	8	6	10	14	8	5	2	1
364	9	6	9	14	8	6	3	4	1
365	3	3	5	13	15	9	8	2	2
366	0	0	0	4	5	12	9	11	19
367	7	11	9	7	8	6	4	6	2
368	2	1	4	4	18	11	12	6	2
369	0	5	5	8	15	5	7	3	12
370	2	4	12	9	14	8	3	5	3
371	4	7	4	10	9	6	6	8	6

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